Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

OCTOBER, 1911.

THE METEOROLOGY OF THE UPPER AIR.*

By J. EDMUND CLARK, B.A., B.Sc., F.G.S., F.R.Met.Soc.

[*Being the Presidential Address, 1911, to the Croydon Natural History and Scientific Society.*]

When last year I addressed my fellow members, who have honoured me by placing me in the chair, which I am now vacating for one† who has long given us able service, reference was made to the three chief forward strides made in the realm of Science during the opening decade of this twentieth century. These are familiar to us as Mendelism, Radiology (if that word may be applied to express the idea briefly), and the exploration of the Upper Air. The first of these was then enlarged upon; the second does not, perhaps, come so entirely into the purview of our usual activities; and it is the more appropriate that, as a worker in our second section of Meteorology, I should turn to the subject of the Upper Air, just as a consideration of Mendelism linked itself with our first Section—the Botanical. This subject, moreover, claims an added interest in view of the remarkable progress made in the last two years in practical flight by man.

Although few definite generalised results had been reached previous to the present century for heights much exceeding one mile (two kilometres), pioneer work of no small value dates back to the early sixties. For moderate heights the first beginning was made one hundred and fifty years before. The astronomer, Professor Alexander Wilson, of Glasgow, and one of his students, in 1749, attached thermometers to kites strung in series. This was three years earlier than Franklin's classic experiment, by which he proved that lightning was an electric discharge.

From that day on, kites have been one of the chief methods for the investigation of the free air in its lower parts, second in importance only to the results in higher parts by balloons. Lofty mountain stations have also afforded many valuable facts. But it is obvious that records so obtained are viciously affected in a double manner, so far as the real state of the free air is concerned, namely, by the disturbing effects of the land surface, with its own conditions of temperature and moisture, and by the dislocation, through the slopes, of the normal atmospheric flow, resulting in profound modifications of temperature and saturation.

For practical purposes only one other source of knowledge remains, that afforded by clouds as to wind direction, saturation, and whether the stratum is above or below the freezing-point. The first scientific work through clouds began with their classification by Luke Howard, in 1803, which, after remaining practically unaltered for nearly a century, has now been re-organised rather than replaced.

* *Authorities.*—Besides the frequent communications during the last few years to the Royal Meteorological Society, and in *Symons's Monthly Meteorological Magazine*, the writer has specially consulted the valuable summary of our knowledge presented by Messrs. Gold and Harwood to the Winnipeg Meeting of the British Association in 1909; Sir John Moore's "Meteorology, Practical and Applied" (1910); Meteorological Office Publication No. 202 (Perturbations of the Stratosphere); "Das Werter"; and Mr. William Marriott's account of James Glaisher's Meteorological Work (1904). There is a very informing article by Professor A. Lawrence Rotch, the able director of the Blue Hill Observatory, near Boston, U.S.A., in *The Scientific American* of October 22nd, 1910.

† William Whitaker, F.R.S., F.G.S.

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The important work carried out through balloons is of the more interest to ourselves, since for thirty years the originator of scientific upper air exploration by this means, John Glaisher, lived in our midst. True, a small beginning had already been made in 1852 by Mr. Welsh, of the Kew Observatory. In 1858, the British Association appointed a committee to investigate decrease of temperature with altitude, but it practically did nothing. A new committee, appointed in 1861, included Admiral Fitzroy, Airy, Brewster, Herschel, Tyndall and Glaisher. After disheartening failures the generosity of Coxwell came to its rescue by offering to build a balloon for their use. Mr. Glaisher responded to this enthusiasm by determining himself to make the observations. Thus began in 1862 the famous ascents by which for the first time approximately correct data were obtained for what we may call the middle region of the atmosphere at present accessible for meteorological records. In the course of three years a height of eleven thousand feet, or over two miles, was exceeded on no less than eleven occasions, including that most famous ascent from Wolverhampton, on September 5th, 1862, to the unprecedented height of about seven miles, when Mr. Glaisher became unconscious and Coxwell, with hands frozen, barely succeeded in pulling the valve cord with his teeth. This height has probably never been surpassed by any balloonist of later years. But no observations were taken above about thirty-one thousand feet, whereas, in 1901, Berson in Germany took records to nearly thirty-five thousand five hundred feet. In this case both men became unconscious, only reviving when they had fallen two-and-a-half miles. In 1875, two out of three French meteorologists were suffocated at a height considerably less.

These disconcerting consequences indicated only too plainly that direct observation by manned balloons was only possible up to six, or, at most, seven miles, and that but rarely, at immense cost. This has led to the present development of free balloons, or *ballons sondes*, a method already suggested by Le Verrier in 1874. It had, indeed, been quickly acted upon, but only in the form of pilot balloons, to determine wind direction and height of clouds, and by these, from 1877 onwards, much valuable knowledge was secured.

While balloon work was thus developing, advances of equal importance were made by means of kites. In 1883, E. D. Archibald first used piano-wire in experiments on wind velocity. His Biram's anemometer was, perhaps, the first recording instrument employed in Upper Air research, but it only gave the total from beginning to end. Two years later began the splendid series of observations which has made the Blue Hill, in Massachusetts, a household word wherever meteorology is followed; and here it was, in 1890, that William A. Eddy devised a form of tailless Malay, or—as we used to call them at school—Dutch kite, which now, as the box-kite, has superseded all others. At Blue Hill again, four years later, was sent up the first continuously recording instrument, and from this date progress was rapid and wide-spreading, for, in 1898, the newly-founded International Aëronautical Committee was already recommending similar work for all stations of the first class, advice which was adopted in France and Russia. Work in England was initiated by Mr. W. H. Dines, especially with flights from tug and shore on the west coast of Scotland in 1902, work since continued for the Meteorological Office, in association with *ballons sondes*, first at Oxshott, since at Pyrton Hill, in Oxfordshire. To him, perhaps, more than to any other person, England is indebted for her present good position in this new field of exploration. The famous French savant, however, M. Teisserenc de Bort, first achieved a height of over a mile, by a kite flown from a Danish gunboat in the Baltic, a height which now has in some instances been nearly trebled. It was not long before our British Office added Upper Air records to its weekly weather reports, as they were taken at Glossop, Pyrton Hill, Ditcham Park and Brighton. At the first station, under the supervision of Manchester University, daily records are made, as far as possible supplemented by balloons when the wind is deficient.

But kites are, of course, strictly limited in height of ascent, and it is with pilot balloons and *ballon sondes** that the recent extraordinary success in obtaining extensive series of records at heights up to and above ten miles have been secured. Thirteen to fourteen miles is perhaps the present thoroughly ascertained limit.† These ascents are made by means of rubber balloons, usually weighing half a pound and about half a metre across, filled with hydrogen and used either singly (sometimes with a parachute), or else in pairs. They are filled sufficiently to burst at a given elevation (one only in the case of a pair, when the other acts as a parachute for the combination) and carry special recording apparatus, carefully guarded against rough shocks when striking ground again. The heights, when possible, are determined by one or more theodolites to check the aneroidogram record, on which alone, more frequently, the observations have to depend.

Besides more sporadic work concerted observations have, since 1901, been made on the first Tuesday of each month by nearly all European countries. To the instruments is attached a ticket with instructions to the finder and the offer of a reward for its return. As a rule more than half those sent up are so recovered, sometimes after a flight of over two hundred miles.

* A pilot balloon gives wind directions at varying heights by theodolite observations; the name, "sounding balloon" is applied more usually to ballonets with recording instruments.

† Some English records have been obtained almost certainly for at least fifteen miles; but the values above twelve miles are subject to serious possibilities of altitude error.

Having thus indicated the manner in which instruments have been and are carried to various heights, a few details concerning them will be appropriate before discussing the results obtained.

Glaisher, in Coxwell's "Mammoth," devoted himself mainly to the relation of height with temperature, and with hygrometric conditions, while not overlooking possible chemical and magnetic changes, cloud forms, changes of air currents, and so on. His outfit included a mercury barometer, aneroid, dry and wet bulb and maximum and minimum thermometers, Daniell's and Regnault's hygrometers, horizontal magnet, electrometer and sealed exhausted tubes. This appalling array for a single observer was set out upon a board, ready in case of danger to be instantly packed for safety. Coxwell acted as time-keeper as well as pilot. Each high ascent cost £50, so that the number available from the British Association grants was limited.

In recent years, of course, self-recording instruments have done the work, those intended for kites being the more solid in form. Yet even the complete set now usually attached to these weighs only one-and-a-half to two-and-a-half pounds, including a clock with recording drum, a large double Aneroid or Bourdon tube barometer, Bourdon tube thermometer,* Robinson anemometer, and hair hygrometer. This and the thermometer are cased in a polished aluminium ventilation tube, having a vane to keep it end on to the wind. This is most essential to ensure true temperature and humidity records. Unfortunately, Glaisher's results were to some extent vitiated from ignorance in his time of the necessity for this. In England, now, the much lighter apparatus designed by Mr. Dines is used; essentially a cardboard disc, revolved by clockwork. On one side of its upper face is recorded pressure and humidity; on the other temperature and wind speed.

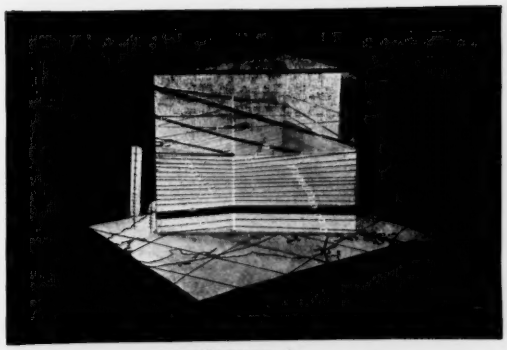
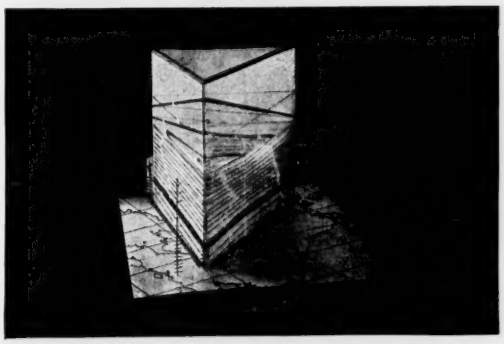


FIGURE 1.



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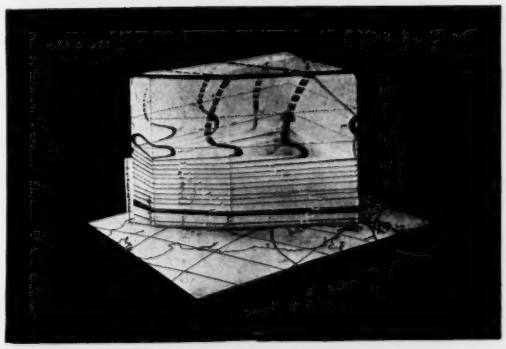
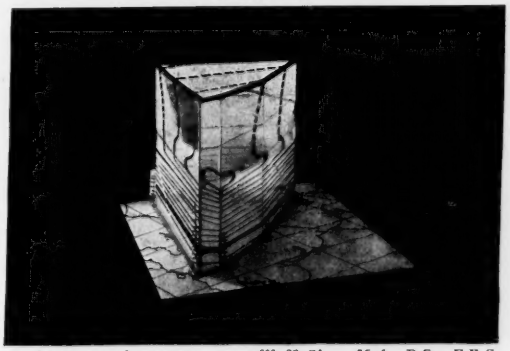


FIGURE 3.



By the courtesy of *W. N. Shaw, M.A., D.Sc., F.R.S.*

FIGURE 4.

Temperatures and Pressures in a block of Atmosphere fifteen miles thick, over a portion of the British Isles, July 27th and 29th, 1908.

For *ballons sondes* still lighter apparatus is required. Out of England the usual instruments weigh about one-and-a-quarter pounds. The German form, perfected by Assman, consists of an endless sheet between two drums. One of these is turned by aneroid changes. Two pens pressed against the sheet are moved at right angles to this motion by changes of temperature and humidity respectively, being attached to the necessary instruments. Time may also, however, be recorded by a small clock, though this is not essential, and the whole is encased.

In England, again, the far lighter Dines' instrument prevails, weighing either three-and-a-half ounces or one ounce. This, however, discards humidity records. The aneroid is attached by one face to the frame, by the other, indirectly, to a parallel rod of invar, a lever from which moves a stylus across the face of a silvered metallic strip, which is attached to the frame. The invar rod is itself part of the metallic thermometer, so that at constant temperature its style makes a parallel scratch, which, however, diverges with a fall of

* Bourdon tubes are circular arcs, the tube exhausted for barometer, and filled with a suitable liquid for thermometer Varying pressure alters the curve.

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temperature. The scale is such that one-tenth inch equals 100°C, so that 1°C, or ·001 inch can easily be read with a low power microscope. A thin strip of German silver is used with the rod of invar, the latter being a non-expanding alloy. The two are slightly separated, and fixed at one end. The pen lever, attached to the free ends, multiplies the difference of expansion some tenfold.* The whole is encased in an aluminium cylinder, open at each end.

Because of this extreme lightness, English results include a larger proportion of records up to twelve miles or so, which is some set off, both to the omission of humidity records and the greater danger of loss by falling into the sea.

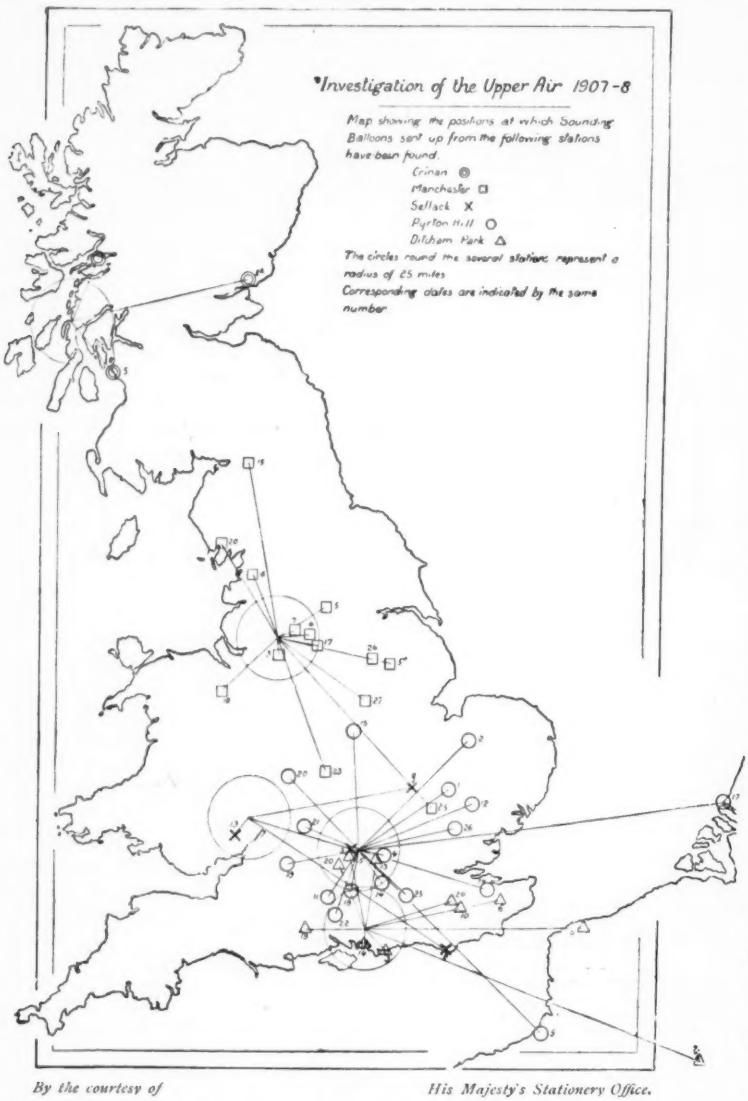

Investigation of the Upper Air 1907-8
Map showing the positions at which Sounding Balloons sent up from the following stations have been found.
Crinan
Manchester
Sellack X
Pyrton Hill
Ditcham Park
The circles round the several stations represent a radius of 25 miles
Corresponding dates are indicated by the same number
By the courtesy of
His Majesty's Stationery Office.

FIGURE 5. Map of British Stations.

As to accuracy Dines is correct for temperature within 0·8°C against 1°C by the Continental records, but the height records are less reliable, the average pressure error being eight millimetres or one-fifth inch, against five millimetres, or rather under one-sixth inch. Although at three miles these errors are only about one hundred and fifty yards, at nine miles they increase respectively to about five hundred and fifty and four hundred and thirty yards, and at twelve miles to over one thousand one hundred (one kilometre) and six hundred and seventy yards.

Finally we turn to the object of all this work and the measure of results attained. As to the former there is now added, so far as the first two miles or so is concerned, the additional desire of knowledge helpful to aviation. This has already borne fruit; for it has been established that eddies and uprush gusts,—most dreaded of all dangers by the fliers,—rapidly decrease as the surface is left.

But the original incentives, other than purely scientific, were more entirely meteorological and practical, namely, to enable the authorities responsible for weather forecasts to attain a yet greater accuracy. So long as surface observations only were available, any complete discussion of the causes and modes of air movements was plainly as impossible as it would be for a geographer thoroughly to survey a country without leaving a railway running due north and south. For just as, to him, east and west observations are equally as essential as north and south for his two-dimension chart, so also does the meteorologist require to work in three directions for his three-dimension chart. Already this has been strikingly illustrated by Dr. Shaw, the capable head of our Meteorological Office, who built a most beautiful and instructive model, in the form of a triangular prism, of the atmosphere to a height of fifteen miles above the British Isles, the angles lying at Limerick, Crinan and Pyrton Hill in Oxfordshire (see Figures 1 to 4). A casual glance reveals the chief and least expected phenomenon brought to light by these Upper Air explorations, to which reference may now be made.

It has been, of course, long known that

* This description follows the construction of the lighter apparatus, as used in 1910.

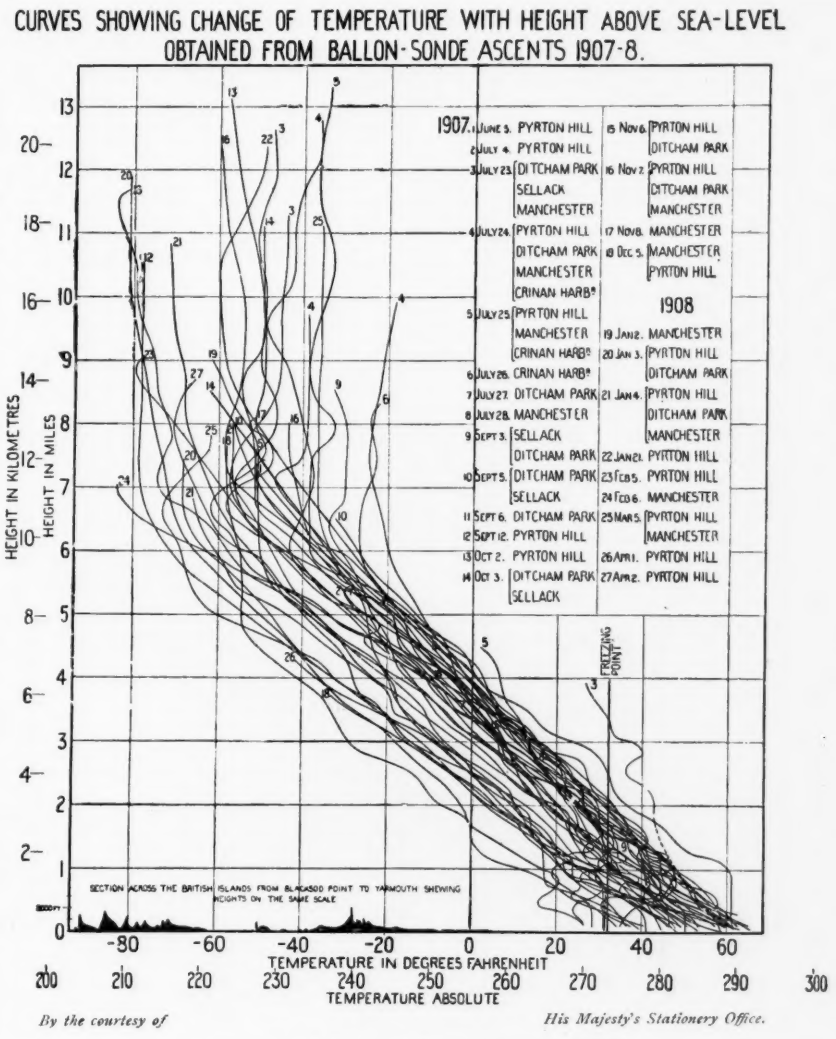
temperature decreases rapidly with height, namely, at the rate of 1°F. for every three hundred feet. It is now well established that, in the lower two miles, this is frequently reversed, a fact previously thought exceptional. But from this height up, as shown by the closely-set parallel lines of the model, there is great and constant regularity. Formerly, it was supposed that this continued unbroken until the cold of space was reached, presumably somewhere near absolute zero, or — 273°C. No one dreamt of any serious divergence. When, however, the *ballons sondes* records began to accumulate, one of the most obvious facts obtained was that at a height, usually of about six miles, temperature *ceased to fall*, and on the contrary tended again to rise, and that this unlooked-for reversal, so extraordinary that as yet we have for it no certain explanation, continues as high as we have at present any observations, namely, at the least up to a height of fifteen miles.

In other words, whilst we still cannot but believe that, outside our atmosphere, the cold of space is intense beyond easy conception, so far as actual knowledge goes, it ceases to grow colder at a height of six miles and remains practically unaltered through, at any rate, the succeeding eight or nine miles.

This layer was first named, very appropriately, the "isothermal layer," but, to connect it with the regions of change beneath, these latter have been called the "troposphere," the upper the "stratosphere." The latter lies above the highest visible clouds.

The average height of the lower surface of the stratosphere, which is, however, subject to considerable local perturbation, alters both with the season and latitude, being, in Europe, least (9·1 kilometres, or about five-and-a-half miles) in March, and highest (11·9 kilometres or about seven miles) in October. The only decided break in the curve is for September, a kilometre lower than August, and one-and-a-half kilometres below October. It is suggestive that here also occurs, at least in the British Isles, the chief break in the rainfall curve. This, also, is the time when the north trade winds are at a minimum, and there may well be some association. The temperature is lowest in February (—80°F.), highest in September (—60°F.).

Observations outside European latitudes are still exceedingly rare, but some special ascents in East Africa, over the Atlantic, and in the West Indies, have given important evidence as to equatorial conditions. Over the Atlantic the stratosphere was not reached at fifteen kilometres, which is nearly nine miles, or half as high again as the European average. It was, however, revealed by two ascents made on the Victoria Nyanza, which reached a mile and three miles higher (ten and twelve miles). Here, in equatorial regions, was recorded the lowest air temperature yet obtained, 119°F. below zero (—84°C). Thus we have the interesting result that the regular fall of temperature continues up

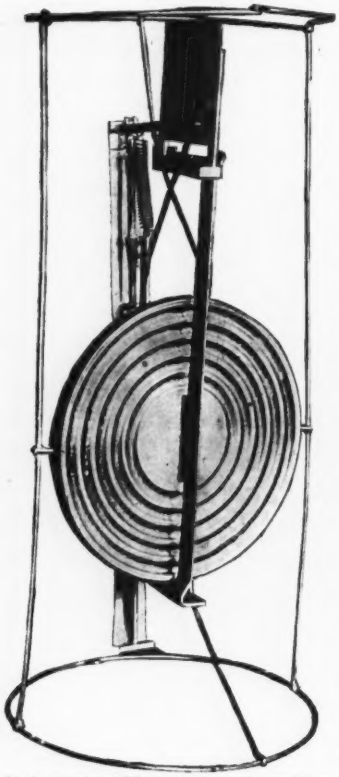

CURVES SHOWING CHANGE OF TEMPERATURE WITH HEIGHT ABOVE SEA-LEVEL
OBTAINED FROM BALLON-SONDE ASCENTS 1907-8.
1907.
1 JUNE 3. PYRTON HILL
2 JULY 4. PYRTON HILL
3 JULY 23. DITCHAM PARK, SELLACK, MANCHESTER
4 JULY 24. PYRTON HILL, DITCHAM PARK, MANCHESTER, CRINAN HARB.
5 JULY 25. PYRTON HILL, MANCHESTER, CRINAN HARB.
6 JULY 26. CRINAN HARB.
7 JULY 27. DITCHAM PARK
8 JULY 28. MANCHESTER
9 SEPT 3. SELLACK, DITCHAM PARK
10 SEPT 5. DITCHAM PARK, SELLACK
11 SEPT 6. DITCHAM PARK
12 SEPT 12. PYRTON HILL
13 OCT 2. PYRTON HILL
14 OCT 3. DITCHAM PARK, SELLACK
15 NOV 6. PYRTON HILL, DITCHAM PARK
16 NOV 7. PYRTON HILL, DITCHAM PARK, MANCHESTER
17 NOV 8. MANCHESTER
18 DEC 5. MANCHESTER, PYRTON HILL
1908
19 JAN 2. MANCHESTER
20 JAN 3. PYRTON HILL, DITCHAM PARK
21 JAN 4. PYRTON HILL, DITCHAM PARK, MANCHESTER
22 JAN 21. PYRTON HILL
23 FEB 5. PYRTON HILL
24 FEB 6. MANCHESTER
25 MAR 5. PYRTON HILL, MANCHESTER
26 APR 1. PYRTON HILL
27 APR 2. PYRTON HILL
FREEZING POINT
SECTION ACROSS THE BRITISH ISLANDS FROM BLACKSOD POINT TO YARMOUTH SHEWING HEIGHTS ON THE SAME SCALE
HEIGHT IN KILOMETRES
HEIGHT IN MILES
TEMPERATURE IN DEGREES FAHRENHEIT
TEMPERATURE ABSOLUTE

By the courtesy of *His Majesty's Stationery Office.*

FIGURE 6. Relation of Temperature and Height.

to the base of the stratosphere, however high that may be.

Wind changes are a second most important element in passing from the troposphere to the stratosphere, especially as to velocity. At times this is extreme. Thus at Ditcham, July 28th, 1908, it fell from over forty-five miles an hour to about six miles. Three days later, however, from over seventy miles, the drop was only to fifty-eight miles. The stratosphere, therefore, is comparatively a region of calm as well as of even temperature. This appears to continue at least up to fifteen miles. But at some higher point there is a reverse change. To dust from the Krakatoa Eruption, in 1883, was assigned an initial height of about thirty miles. At this height, which is just double that explored by recent investigations, was found over the equator an east wind that carried the dust with a velocity of some seventy to eighty miles per hour. At a height of about fifty miles the long enduring streak from the meteor seen on February 22nd, 1908, travelled with velocities up to and over one hundred miles an hour.



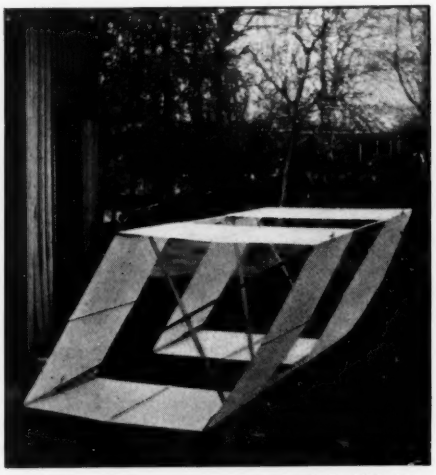
By the courtesy of His Majesty's Stationery Office.

FIGURE 7. Dines' Balloon Meteorograph.

We must not forget that the assumed extent of the Earth's atmosphere, some two hundred miles, is at least fourfold this height. Its density still suffices to raise meteors to white heat, by friction, up to about one hundred miles.

Observations at Potsdam indicate that, with a mean surface velocity of twelve miles an hour, the speed is seventy-five per cent. greater at a height of five hundred feet, and a hundred per cent., or doubled, at rather over the mile. It is trebled at about two miles, and above three miles rises to over fifty miles an hour. Up to fifteen hundred feet the velocity almost always increases, but it frequently falls off higher than this, especially with South-east winds. The velocity just below the stratosphere may exceed two hundred miles per hour.

The interest and importance of the unexpected results detailed above must be the excuse for dwelling upon them at such length, so that other very valuable discoveries must remain without reference. But what has now been said suffices to indicate that, as in the case of Mendelism and Biology, the advances of Meteorology in the region of Upper Air exploration during the opening decade of the twentieth century are destined long to stand in the foremost ranks of scientific achievements.



By the courtesy of H. R. Mill, D.Sc.

FIGURE 8. Dines' Box Kite.

METEOROLOGICAL PHOTOGRAPHS.

THE United States Weather Bureau is forming, in its library at Washington, a collection of meteorological photographs, and will welcome additions there to from all parts of the world. The following classes of pictures are among those desired:

1. Views of meteorological offices, observatories and stations.
2. Pictures of meteorological apparatus.
3. Portraits of meteorologists; views of their homes and birthplaces.
4. Views showing the effects of storms, inundations, freezes, heavy snowfall and so on.
5. Cloud photographs.
6. Photographs of optical phenomena (rainbows, halos, Brocken spectre, mirage and so on).
7. Photographs of lightning and its effects.
8. Photographs of meteorologically interesting pictures in old books, or of early prints and paintings. (*e.g.*, contemporary pictures of the damage wrought by the Great Storm of 1703, in England.)

Persons who are willing to present such pictures to the Weather Bureau, or who will furnish them in exchange for Weather Bureau publications, are requested to address:

Chief U. S. Weather Bureau,
(Library.) Washington, D. C.

It will add much to the value of these pictures if the sender will kindly note on the back of each as much pertinent information as practicable. On picture of classes 4–7, inclusive, should be stated at least the date, hour, and place at which each picture was taken, and the direction toward which the camera was pointed.

THE NEW ASTRONOMY.

II.—DOUBLE AND WONDER STARS.

By PROFESSOR A. W. BICKERTON.

THE Star that rules our planetary system is a comparatively steady and commonplace luminary. The Sun has its storms, but for thousands of years no one knew of them. He is neither strikingly large nor inordinantly small. Sir David Gill says: "Our Earth is a very insignificant planet revolving round a very insignificant Sun." The more the stars are studied, the more complex a very large number are found to be, and some hundred thousand are larger than our Sun. Scores of thousands of them are double, and between one and two thousand of them are known as Wonder-stars because they exhibit fluctuations of intensity. In 1596, Fabricius missed a star that he had seen some little time before. Then again in a few months he was astonished to see it once more. He soon found that there was a rough regularity of a little less than a year in its waxing and waning period. Because it was in the Constellation of the Whale and such an extraordinary star, he called it Mira Ceti, or the wonderful star of the Whale. Although we now know over a thousand variable stars, this *o* Ceti or the star Omicron of the Constellation of the Whale, is perhaps still the most remarkable Wonder-star of the entire heavens, and probably many astronomers would have to admit that they know as little of the cause of its remarkable fluctuations as did its discoverer Fabricius.

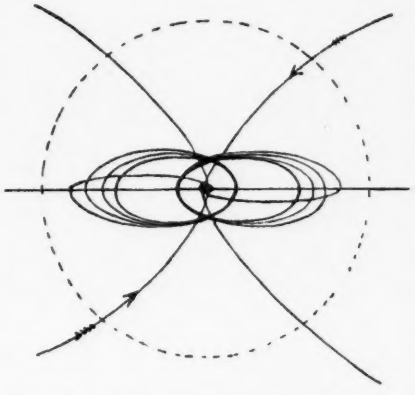


FIGURE 9. Diagram showing the formation of the orbit of a Double Star.

The dotted circle represents the nebula expanding beyond aphelion distance.

The two continued hyperbolas represent the path of the two stars had there been no collision. The collision occurring, the orbit becomes a long ellipse, that becomes of less eccentricity because the nebula has expanded.

The meteoric nucleus left behind by the third body will produce a resistance at perihelion and this will tend to make the orbits more circular, as shown in the diagram.

Another very remarkable variable star is named Algol, or the Demon star, and this has also been known for a great many years. Mira seems to have every kind of irregularity of variability, whereas Algol is as regular as a clock, and the cause of the variation of this star is well known. The Demon is a double star, consisting of a dark and a luminous body, and the variation of its light is due to the dark sun coming in front of the bright sun and eclipsing it once in every revolution. Some of these variable stars take more than a year to go through their cycle, and some only a few hours. They vary in all kinds of different ways, but apparently there are but few of them but may be explained on the principle of "partial impact" and "the theory of the third body."

Leaving actual observation we will return to deduction and try to trace dynamically what must happen to the two torn suns that we have assumed to have cut deep valleys in one another, and that have passed one another and are increasing their distance in space whilst leaving between them the exploding star. One of the first things we must study is the effect of the attraction of this temporary third star upon the two escaping suns. In the story of Nova Persei some few of the salient properties of this third star were discussed. One was that it is thermodynamically unstable, and hence it necessarily explodes. Consequently it is quite certain that when suns do graze they actually must produce a nova. The property we have now to speak of is the power of this body to capture. This property, like its thermodynamic instability, does not seem to be one that is easily grasped by observational astronomers. The power of the third star to capture, tends to make the two torn suns into a pair; that is an orbitally connected double star. Supposing that two equal stars have each grazed off a sixth, the new third body will have twice the mass lost by either. Each torn sun will have a mass of five-sixths of what it had before the collision, and the third star two-sixths of one of them. Each of the two retreating stars is subject to the attraction of the other torn sun, and of the new star. That is, each of the suns when at similar distances are subject to an attraction of seven, whereas before the impact they were subject to an attraction of six. But the third star remains at rest in space, and the two torn suns are flying from each other, so that the attraction of the third star is effective longer upon each of the

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torn suns than they are upon one another. Consequently the effective attraction is more than seven, is really equivalent to about nine, that is one-and-a-half-times as much as before the collision. If the stars had any proper motion before attraction brought them together the orbit at impact would have been a hyperbola, generally very close to a parabola. After the collision the additional attraction will in very many cases convert the orbit into an ellipse and consequently the two torn suns will be wedded by the influence of the third body into an orbitally connected pair, that is, into a double star (see Figure 9). If the proper motion were large, and the graze small, the capturing power of the third body would not suffice to wed the two stars into a binary. The number of pairs of variable stars that are too far separated to be considered physically-connected binaries seems to suggest that this must happen frequently. A list of some of these pairs of variables that were found in less than a thirtieth of the celestial vault is given on page 89 of "The Birth of Worlds and Systems."

It has been argued by astronomers that the orbit of double stars that had been wedded by impact, must be such as to cause the stars to collide again at every periastrum. This, probably, as a rule, is not the case, but occasionally such recurrent impacts apparently take place. Agencies, however, come into play that tend to prevent recurrent impacts; these agencies are fully discussed in "The Birth of Worlds and Systems." We will give one very efficient agent that tends to prevent recurrent impact. The pair of torn suns are wedded by the attraction of the third body, but this third body is largely dissipated before the two stars reach their greatest distance. Hence it is not there to attract them back again. Consequently they do not approach so near one another at periastrum as they would have done had the third star remained the same mass that it possessed when first formed. The several factors fully account for the low eccentricity of many binaries. There is great reason to imagine that both Nova Persei and Mr. Espin's star are cases of recurrent impact. In the case of Nova Persei a peculiar concentric-looking nebula existed before the impact took place that produced Nova Persei itself. As exactly such a nebula might have been produced by a previous impact, this idea of recurrent impacts seems to furnish a sufficient explanation of its existence. The accompanying Figure 10 is one of those taken as the nebula was progressively lit up by the flash of light that was produced by the exploding third star—the flash we saw and named Nova Persei. We have every reason to suppose that this was the case, because, as the light was progressively reflected from the whorls of the nebula, it showed the characteristic blaze band spectrum that was so unique a peculiarity of the flash period of Nova Persei.

The reason why we may think of Nova Lacertae as being the third body produced by a recurrent impact, is that one of the two stars that came into impact in this case appeared to have been a variable star before the partial impact occurred that produced this apparition. It may be worthy of note that one of the dynamical deductions as to the properties of the third body is that it passes through the stage of being a planetary nebula. Nova Lacertae is now said to have become a planetary nebula.

I cannot enter into greater detail here because the "theory of partial impact, and the third body" is so wide as to really constitute a new cosmogony. I would refer students to the original papers in the transactions of the New Zealand Institute, for the years 1878, 1879 and 1880. These are in all the important libraries of London.

If double stars are produced by the grazing impact of suns, in their early days they must have exhibited the scars produced by the encounter and sometimes be doubly variable; but there are many reasons why this scarred condition should last very much longer in some stars than in others. Consequently we should expect to find a comparatively large number of double stars that exhibit variability and a few that show double variability. There are several double stars actually known to be thus doubly variable, quite a large number of double stars that are single variables, and still more double stars that are coloured, a state which has been deduced as being a final condition of variability before the torn suns have healed completely and once more become normal stars.

It would be an extremely important piece of work were some of our amateur astronomers to find the many variable stars that are double, and especially the many spectroscopic binaries that are variable and in which the variability is not due to eclipse. Mr. Espin and Mr. Victor Anestin, have already found some most valuable and remarkable results in connection with double stars, their association with the various classes of variable stars and with density of star distribution.

Let us now examine in some detail the condition of these torn suns with respect to the distribution of the material, and the character of the motions developed in the suns that have come into grazing impact.

Nearly the whole of the dynamical conclusions regarding the grazing impact of suns were worked out over thirty years ago, and they have been subjected to endless debate and calculation on the part of mathematicians and astronomers. If we grant the fact that collisions must occur, as on the grounds of the doctrine of probability seems inevitable, we have an actual explanation of the phenomena of temporary, variable and double stars, for we cannot doubt the accuracy of the thermodynamic deductions that are here presented.

When these basic deductions are combined with the fact that there appears to be scarcely a single one of all these complex deductions but has been confirmed by observations, we must admit that impact, if not of the supreme importance that is suggested by these researches and observations, must be a stupendously large factor in cosmic

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evolution and worthy of the most careful and detailed study on the part of astronomers.

The diagram, Figure 11, page 382, taken from "The Birth of Worlds and Systems" was drawn to show the distribution of material at the moment when the three bodies are parting company. Assuming the similar suns to be of average dimensions, we can imagine the valleys which have been cut along the equators of the two torn suns to be perhaps something like a million miles in length. The valley commences with a mere scraping away of the atmosphere; it then becomes deeper and deeper, until it reaches far down into the sun. The material is dragged forward, and at the moment of parting with the new third star, it is heaped up into a huge mountain of fire, hundreds of thousands of miles high. This material being carried by momentum in the direction in which it has been dragged, tends to follow the third star, and so produces rotation in the general plane of the orbits of the two stars.

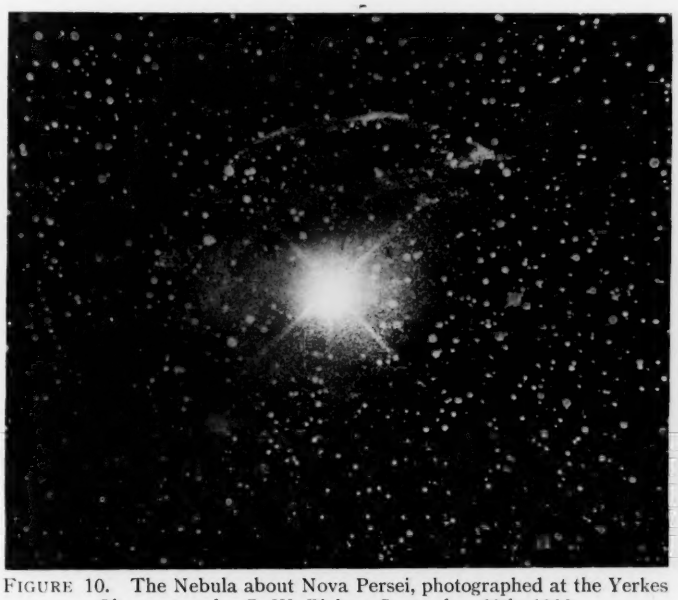

FIGURE 10. The Nebula about Nova Persei, photographed at the Yerkes Observatory by G. W. Richey, September 20th, 1910.

In all probability before the impact occurred the star had a rotation of its own, and hence, immediately after the impact, a tumult of conflicting motions of the most extraordinary character must ensue. There is first this struggle of the two rotations, the original and the impressed rotations, that must result in a most extraordinarily irregular rhythm. Then, again, we have gravitation exerting itself, struggling to make the highly-distorted body into a sphere. We have to remember that not merely is there the enormous disturbance in the form of the torn sun due to the impact itself, but there is the disturbance due to tidal action, and although it is possible that Chamberlain and Moulton greatly exaggerated this action, still tidal deformation must be of a stupendous character. Hence we have gravity struggling to make this ill-formed mass into a sphere. A tremendous inertia of motion will be set up whose momentum must carry the material past the position of equilibrium, and thus another amazingly irregular tidal action must be at work in each of the two torn suns.

This heated mountainous mass must produce convection currents of ordinary gas and volatilized metals, and when this is projected, as it must be, in many cases, for hundreds of thousands of miles above the surface of the star, in certain positions this must produce bright line spectra. Especially will such spectra be crossed by the bright line of hydrogen, and this deduction has been conclusively borne out. In fact, not merely are these stars known to be thus characterised, but hundreds of them have actually been discovered by especial search directed to the finding of such bright lines. Amongst the variables so discovered, some have proved to be doubly variable double stars; that is to say, double stars that have been so recently wedded by attraction of the third body that they may be actually considered to be on their honeymoon.

It will easily be perceived that all the struggles of motion and the changes in the margins of these vast volcanoes must alter in the most extraordinary degree the intensity of luminosity at the period of maximum. It must even alter to some extent the time of the apparent maximum itself.

It might be thought that this complex series of motions, as well as conduction and convection, would rapidly bring about a condition of equilibrium; hence that this inequality of heat of the rotating star would not last long.

A detailed study into all the conditions that presented themselves was made in 1879, and it was shown that a great number of the agencies tending to equality balanced one another and became ineffective. Hence it appeared at that time—and the opinion has not altered since—that approximate equality would not be attained for many hundreds, or in some cases thousands, of years. One of these factors, convection, may be due to lightness, produced either by high temperatures or by low atomic weight, and a study of these two characteristics will show at once that the two are tending to counteract one another.

We have already referred to the fact that atom sorting, or molecular escape, will tend to leave behind, in the third body, a rotating swarm of nebulous meteoric dust. In most cases, a good deal of this may be associated with the torn suns, and the torn suns would also, by the extraordinary violence of the volcanic ejection, tend to produce vast atmospheres. It is clear these atmospheres must tend greatly to alter the character of the

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luminosity produced. One point is obvious, the variable star is sending its vast revolving searchlight through the whole circumference of the heavens. When it is shining away from us it will light up all those dust particles that are on the further side, and illumine them as the Sun does our satellite when it is full moon. Hence we have an obvious explanation of the phenomenon that characterises a number of variable stars, namely, that they present a nebulous appearance at minimum, that is, when the star is sending the searchlight of its vast volcano away from us. Such, then, are some of the characteristics of the torn suns. We also see how amazingly impacts must differ the one from the other: collisions must occur between suns of great difference of mass, of differences of density, of age and hence of luminosity, and then again we have collisions from the mere graze of the atmosphere to almost direct impacts. We may have impacts in which the size of the two impacting bodies are so unequal that the one may bury itself in the body of the other, and produce a gigantic volcano, such as I have imagined to have originated the variability of Mira. I have discussed this in "The Birth of Worlds and Systems."

FIGURE 11. Diagram* showing material dragged to the preceding end of valley.

Some scientific men have objected to the minute detail in which I have described the phenomena deduced as following grazing impacts. They say that we cannot know the exact circumstances, as every conceivable variety may occur; but grant that we have suns anything like approximately equal, and of the compactness that characterises most of them, then there are sixteen well marked characters and basic properties that the third body must exhibit as deduced dynamical generic principles.

FIGURE 12. Diagram* showing why the light in recently torn variables rises quickly and falls slowly.

Obviously we cannot describe a tithe of all the endless possibilities of variation, but we will just take one kind and imagine pairs of similar suns coming into collisions in which the impacts differ from a mere graze of atmospheres down to the almost direct collision, similar to that which in all probability originated our solar system.

With a very shallow graze we have an evanescent flash of light, and the formation of a pair of variables that will continually increase their distance from one another, due to the original proper motion not having been wholly destroyed by the very slight attraction of the small third body.

The pairs of variables given on page 89 of "Birth of Worlds and Systems," are examples of shallow grazes, of course much deeper than the mere atmosphere. Nova Persei is an example of a deeper graze although shallow. The Pilgrim star of Tycho Brahé was a still deeper. Nova Persei appears once to have struck deep enough to have wedded it into a double star. Then we pass through grazes deep enough to produce double stars that are capable of being separated only by powerful telescopes. With still deeper grazes it is dynamically certain that the collision must result in spectroscopic binaries in which the stars revolve around one another in periods of only a few days; of such a type is Algol, and the Cepheids. The variability of several of these appears to be due almost entirely to mere eclipse, the great volcanoes that were existing at the time they wedded have died down; but a surprising number of these stars, both eclipsing and otherwise, still show the blaze of the volcanic scar that was produced by the tremendous blow of their encounter. Again, we go to deeper grazes and the stars scarcely separate, the vast meteoric nucleus of the third star remains as a huge tongue of fire joining the revolving stars into one immense dumbbell-shaped mass of fire. The torn suns themselves, although one vast fiery mass, may still show signs of the giant volcanoes that are still active on the surface, but tidal action has stopped independent rotation, and all changes of brilliancy or of character are synchronous with revolution, because revolution and rotation have become isochronous the one with the other. The best example of this is Beta Lyrae.

When the depth of the graze reaches to a cut of more than a third, unless the original proper motion was enormous, the capturing power of the third body becomes so very great that the three stars do not part company, but whirl around one another as a huge bun-shaped mass. There is every reason to suppose that some of the Wolf-Rayet stars have originated in this way, and their spectrograms tell us the story that this is the mode of their genesis. This fusion we call cases of "whirling coalescence."

Still deeper collisions, and suns revolving slowly are produced. It would seem by the low angular velocity of our Sun that this must have been its origin. It has been suggested in my various books on the subject, that planets did not originate from the body of the sun, but were step-sons and daughters that belonged to one or both of the original bodies whose coalescence made up the Sun.

Professor See has called his great book "The

* From "The Birth of Worlds and Systems," by kind permission of Messrs. Harper and Brothers.

Capture Theory" in order to emphasize this same fact; he has independently deduced the idea that the planets could not have originated from the Sun, and has most conclusively demonstrated the erroneous nature of all the old hypotheses. Thirty years ago I showed that the surface velocity of the Sun would have to be increased some forty thousand times its present amount to enable matter to separate itself and remain independent of the body of the Sun.

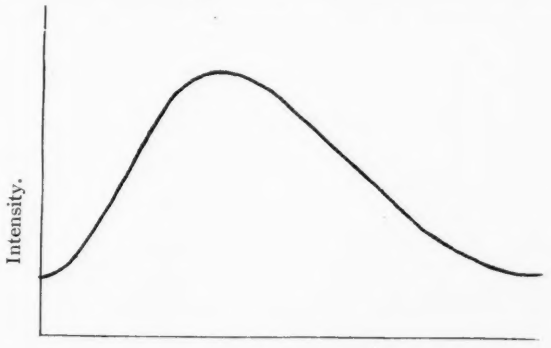

FIGURE 13. Deduced light curve of single variable in which the impact was of recent date, hence the light rises quickly and falls slowly.

Another variable is probably near this star, or it may be one of an orbital pair: its spectrogram should show bright hydrogen and perhaps other bright lines during portions of each revolution: nebulosity at minimum may be expected.

The spectral lines of planetary nebula should be looked for in all spectroscopic binaries, all variable and Wolf-Rayet stars. The pairs of variables on page 89, "Birth of Worlds and Systems," should be examined both for planetary nebulae lines and for nebulosity. Midway between the pairs, the meteoric residue of the third body should be sought for.

Since I have been in England I have devoted many months to the study of the light curves, the spectrograms, and other peculiarities of variable stars, and there is not one amongst the whole that I have studied but seems to have originated in some form of impact. The extremely singular light curves and eccentric distribution of variables in star clusters received fairly satisfactory explanations. The eccentric light curves of the Cepheids received most satisfactory explanation. Eta Aquilae is perhaps the most typical of these stars. It is a spectroscopic binary of a little over seven days period. We must assume that in so close a pair, tidal action must have made rotation isochronous with revolution. It appears that the impact occurred a sufficiently short time ago that the volcanoes of impact exist in both the stars. As the pair revolve, first one of these and then the other comes into view, giving us the well-known curve of the Cepheids. Perhaps the most wonderful example of the combination of many deductions in one pair is the doubly variable nebulous double star, with an oscillatory orbit, that we worked out in Sydney during the time I was there two years ago. This star, also S.S. Signi, and a number of other peculiar variables, I have described in detail in "The Birth of Worlds and Systems."

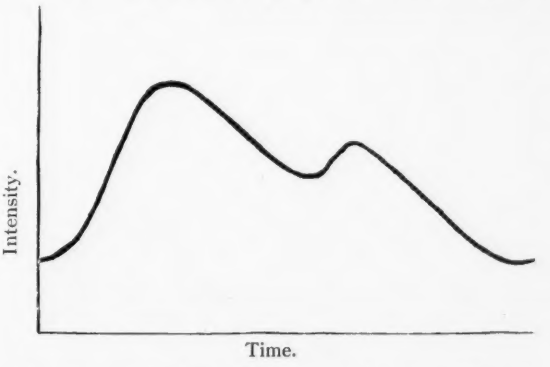

FIGURE 14. Deduced light curve of a non-eclipsing spectroscopic binary.

Associated by impact at a comparatively recent date.

Tidal action has made the time of rotation of each sun synchronous with the period of revolution.

The volcanoes remain active in each sun. The phases of the volcanoes being approximately half a revolution apart, the spectrograms should intermittently show bright hydrogen lines.

Nebulosity should be looked for with long exposure and great light gathering power.

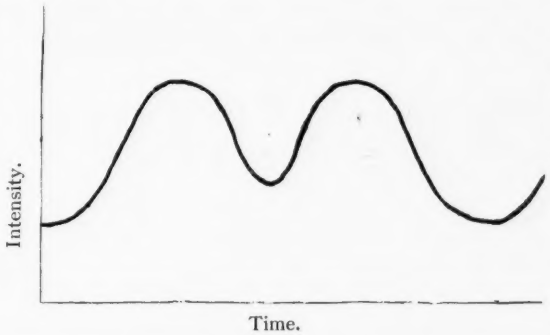

FIGURE 15. Deduced light curve of eclipsing spectroscopic binary produced by impact of nearly a third, hence the pair has just escaped whirling coalescence.

The cuts in the torn suns were so deep, and the third body consequently so large, that each star has been greatly heated and so extensively bathed in the volatilized shining fluid, as to have become a luminous sun. Much of the third star will remain partly as a tongue of fire joining the two torn suns; partly as a nebulous and gaseous atmosphere, this latter giving bright lines. Perchance the nebulosity may occasionally give the star a hazy definition, especially with long exposure. In case the impact that produced this combination be of recent date, a hump of light may indicate the volcano of impact on one or both the suns, and may show on the light curve. Possibly the lines of a planetary nebula may be detected if carefully sought for by means of an analysing spectroscope.

In the next article, after a few words devoted to star clusters and planetary nebulae, we will discuss the phenomena that may be deduced from the impact of White Nebulae and the interpenetration of vast Stellar Systems such as the Magellanic Clouds or the Galaxy itself.

NOTE.—ASSOCIATION OF VARIABLE STARS WITH NEBULOUS MATTER.—It is well to understand the thermodynamic intensity of the volcanic ejection of solar volcanoes. Ejections from so calm a body as our Sun run into velocities of hundreds of miles a second. Compare the speed of 200 miles with half-a-mile a second, which is the velocity of our swift projectiles. $(200 \times 2)^2 = 160{,}000$, that is, the energy of a Krupp shell would be 160,000 times greater than it now is, were it moving as swiftly as some solar protuberances. This then is the order of the Kinetol of projection in the torn suns.

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THE ZOÖLOGICAL SIDE OF COMMERCE.

HORSE-HAIR.

By HUBERT H. POOLE AND WILFRED MARK WEBB.

THE part which animal products play in our every-day life is very important indeed, and many of them go through very elaborate processes of preparation. The whole subject is attractive, and especially so in the cases where there is no possibility of the creatures most directly concerned being ruthlessly exterminated.

We therefore propose to contribute a series of articles on commercial zoölogy to the pages of "KNOWLEDGE," and while all will be of general interest, some of them will have a special attraction for the specialist who deals with the groups to which the animals in question belong.

Mammals are at one end of the scale, and their most characteristic external feature is the presence of hairs. Indeed, there is practically no member of the class which does not produce hair at one stage or another of its existence. That of the horse is especially well developed on the neck and tail, proving ornamental in both instances, but in the latter also useful for brushing away flies, which often are a great source of irritation.

FIGURE 1.
Sorting the horsehair over suction screens.

The horse-hair used for commercial purposes arrives in bales up to half a ton in weight, and a hundred and twenty pounds in value. The chief sources of supply are Great Britain, North and South America, Australia, Germany, Russia and China. The tails are the best, because the hairs are hard, the manes being soft and therefore of inferior value. The specially long hairs are, of course, suitable for particular purposes, but we will deal

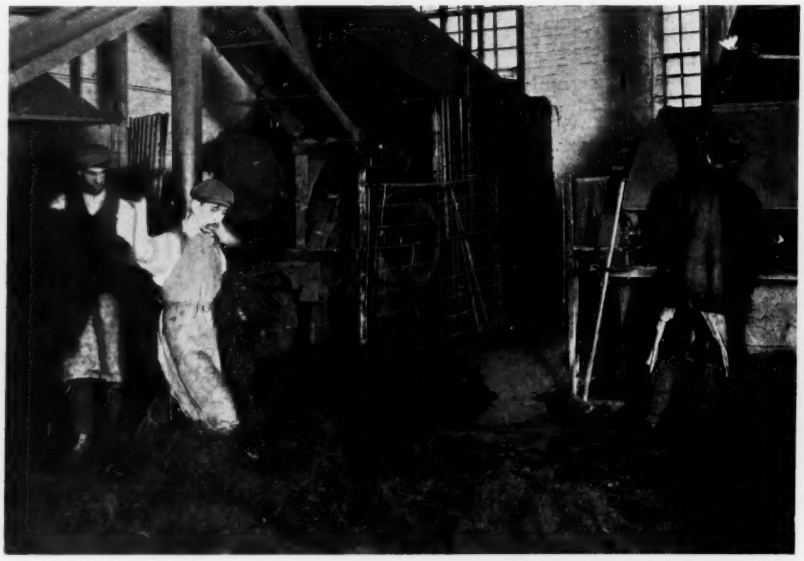

FIGURE 2.
Mixing various kinds of hair together.

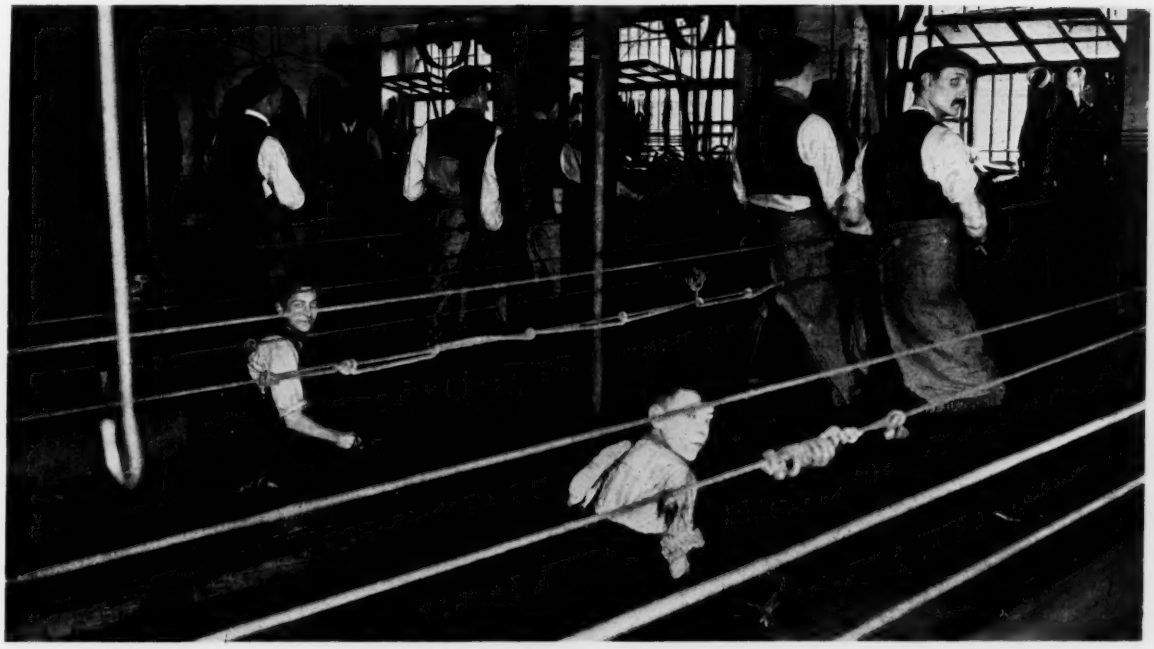

FIGURE 3.

The walk in which the horsehair for stuffing purposes is twisted into ropes.

first of all with those of ordinary length, which are to be prepared for stuffing furniture, and no one who has not seen the process would imagine how elaborate this is.

The hair is first sorted over suction screens (see Figure 1), which draw out the dust and carry it away. Colour forms the first basis of classification, black, white and grey hair being distinguished, and after this the hair is divided up according to its various lengths and its quality. That which is to appear black is dyed in log-wood, washed and dried, and then, as is shown in Figure 2, the various hairs

FIGURE 4.

The careful untwisting of the rope after steaming and drying.

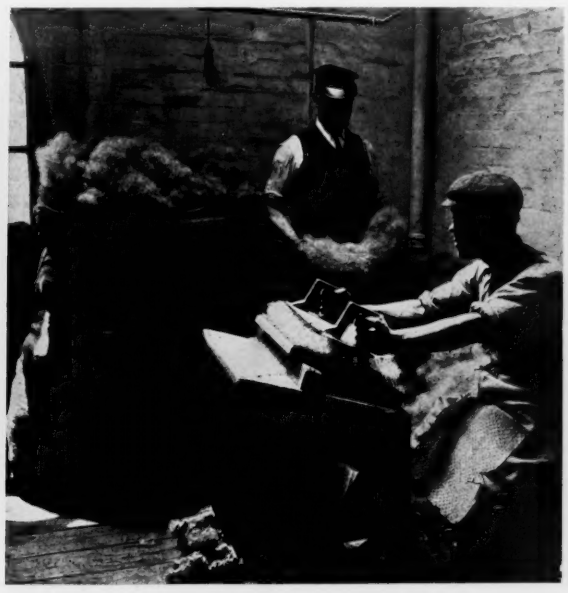

FIGURE 5.

Hand carding the untwisted horsehair from the ropes.

are mixed together on the floor so as to make stuffings of various prices. After this the material is passed through a series of mixing machines or mills, which are provided with exhausts for taking out any dust which remains.

FIGURE 6.
Horsehair ropes hanging up to dry.

Now comes the most curious part of the process. A short walk is provided something similar to that on which hempen cords are made and here the hair is twisted up to form ropes. Each pair of workmen is followed by a boy who beats up a fresh supply of material and that which is dropped, with two sticks, thus getting it ready for the use of the twisters. The ropes are again twisted upon themselves, soaked for two hours in water, then baked at a temperature of upwards of 350° F. for twelve hours. The damp heat, as may be well imagined, destroys all bacterial life that might possibly exist in the hair, and at the same time fixes the curl. The ropes (see Figure 6) are hung up to cool for three days. The low qualities are then untwisted and carded by machinery, though this process is liable to break the staple (see Figure 7). The good qualities are opened out (see Figure 4) and hand carded, the opened twists being placed on the bent pins of the carder which give somewhat, as they are fixed into leather that is in turn fastened to a board.

The hand carding process is shown in Figure 5, and finished horsehair is to be seen in the background. The finer the quality the smaller the rope and tighter its coils. The hair from English cart horses is the best, because it is the strongest, and for the highest qualities long hairs are used. The very finest grades cost up to seven shillings per pound wholesale. Black hair is usually somewhat stronger than the white, but Queen Victoria, who was very partial to horse hair mattresses, always had the best quality of white hair. As it takes about forty pounds of hair to make a full sized mattress, it will be seen that the cost is somewhat considerable.

One man in the employ of Messrs. William List & Sons, who very kindly gave facilities for this article to be written, can boast of over sixty years' service, while several can claim over forty. The men train their sons, as a long experience is necessary in nearly all the processes.

Messrs. List get the longest tails from China and Russia. These are disinfected before they are handled, as a precaution, and after being dipped in a bath of soft soap and soda, are wet hackled (see Figure 8) to get out all the short fur. The sorted hairs are dry carded, being piled up on a board which is studded with long pins and drawn from the two

FIGURE 7.
Untwisting and carding the ropes of the lower grades of hair by machinery.

FIGURE 8.
Wet hackling the long hairs which are not used for stuffing purposes.

FIGURE 9.
Drawing out the hairs and sorting them into various lengths.

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ends between an old razor and the thumb to lengths down to five inches (see Figure 9).

White hair which is thirty inches long and upward is used for violin bows. This is exported largely to Germany by Messrs. List. Black hair, which as we have said before is slightly stronger, is used for the bows for double basses. Shorter hair, according to its length, is tied in bundles and sold to brush makers or to plume makers, for whom it is dyed various colours for ornamenting helmets and the bridles of cavalry horses.

A more extensive use of the long hair is for weaving it into seatings in which a linen warp is used, while the hair cloth which tailors employ for stiffening garments where elasticity is required is made with a warp of cotton. The widths vary from sixteen to thirty-four inches, and it may be pointed out that to produce a thirty-four inch cloth the hair must be thirty-eight inches long. Some of the hair is of exceptional length, and one tail in an extreme case which passed through Messrs. List's hands measured seventy-two inches. The brown hair is used for fishing lines and was much in vogue years ago for cod fishing. One advantage of the old method was that only healthy fish were caught, while now, it stands to reason, the trawls will bring up all that come in their way, whether they are in good condition or not.

Wigs for judges and barristers are made from what is known as "dead" hair which has no glint upon it, and is specially picked out for the purpose.

The hair from the tails of cows and oxen is also used for one or two purposes. The ends of the tails themselves are brought over attached to the skins and always show a twist. This with the very rarest of exceptions is in one direction. The cow tails are dressed whole and undyed (as are sometimes horse tails from South America), for export to South Africa, where they are used for personal adornment by the natives. The latter insist on the hair being undyed, and they plait it into bracelets and over gourds used for snuff, as well as combine it with the wire which is put over sjamboks and sticks. They also use it for threading beads. North American Indians use dyed hair for the same purpose, and for weaving into their moccasins.

The cow hair is also drawn for weaving into sieve bottoms to form strainers for cooks and gun-powder manufacturers, while horse-hair bags are used for oil and cider presses and for brewers' straining-cloths.

Lastly, goats' hair from China and Tibet, being very soft, is used for babies' brushes. But the making of brushes generally is a subject which may well be dealt with in another article.

Figure 10.

Specimens of the hair before and after it has been put through the various processes.

SOME NOTES ON PLANT PHOTOGRAPHY.

By SOMERVILLE HASTINGS, M.S.

Author of "Summer Flowers of the High Alps"; "Toadstools at Home."

IN the following pages I want to try and give the results of a fairly extensive experience of the photography of plants, both in monochrome and colour (autochrome). This has been, for the most part, out of doors, but I have also done some indoor or studio work. I must, from the very first, frankly admit that I know very little of what other workers have written on the subject, what little knowledge I possess being derived almost exclusively from my own experience and failures, so that I can safely say that all the suggestions herein contained I have myself tried and found to be of value.

FIGURE 1.

To illustrate the use of the Swing-back in Plant Photography.

THE CAMERA.

Let me first of all tell you of my apparatus. I am, at the present time, using a quarter and a half-plate camera for field work and another half-plate camera mounted on a special stand for the studio. By a simple device, the reversing back of my quarter-plate camera can be attached to both half-plate instruments so that I am able to use my quarter-plate slides and changing boxes with all three cameras. These are very ordinary instruments of no special make. They give double or triple extension and have rising fronts, though I never use this attachment. What I do consider of importance is a swing-back giving a large range of movement in the vertical direction, and a side swing as well; and perhaps I had better, first of all, try and explain why these attachments are so valuable. I use the swing-back in exactly the opposite way to that in which it is generally used, not for reducing distortion at the expense of focus, but for the very reverse effect. By the help of a swing-back, any plane surface, whatever its inclination to the plane of the camera, can be readily focussed. Suppose, for example, we are photographing a plant, say a snowdrop, as it grows in the vertical plane, with the camera pointing obliquely down upon it. Such an aspect has the advantage that in it we get the ground immediately behind the plant or surrounding objects as a background, whereas, with the camera on the same level, the plant stands out against distant objects or sky, and the sense of proportion is lost. Morever, it is much more convenient to focus in this position. Suppose then that the camera is tilted and directed obliquely down upon the plant with a large aperture to the lens, and we have focussed the flowers on the screen (AB) (see Figure 1), the lower leaves and base will be hopelessly out of focus. The natural tendency under these conditions is to throw backward the swing-back so that the focussing screen becomes more vertical (AB^{I}). But the effect produced will be just the reverse from that intended, the lower leaves will be still more out of focus. What we have to do is to throw forward the swing-back, so that its inclination to the vertical is increased (AB^{II}), that is, to bring the upper part of the focussing screen nearer to the object focussed, that is to the lower leaves. When, however, we are looking down on a group of plants near the ground, when, in other words, the object to be focussed is more in the horizontal plane, the swing-back is used in the reverse manner and the focussing screen becomes more vertical. Not infrequently also, when a row of plants is being photographed, the most satisfactory point of view is not directly in front but rather to the side, and in this case the side swing, used very much as described above, becomes extremely useful. By means of an efficient swing-back, therefore, any plane surface, whatever its position, can be focussed, and although undoubtedly a certain amount of distortion results, as we are photographing plants and not architecture, this can generally be neglected. So that, to return to the subject under discussion, in selecting your camera be sure and see that the swing-back has an extensive range of movement and that there is a side swing also.

TILTING TABLE.

Another necessity for satisfactory field work is a tilting table so arranged that the whole camera slides backward and forward upon it. As I have never been able to purchase one of these and have always had to have it made, I may as well describe it in

detail. I have never found a ball and socket top to the stand sufficiently rigid and have always had to use a tilting table. It is important that this part of the apparatus shall be firm for small degrees of tilting as well as large, otherwise, when the dark slide is introduced, the whole thing slips, and the photograph obtained is not what was intended. To achieve this, it is essential that the locking screw (A, Figures 2 and 3) be as near as possible to attachment screw (B) when the tilting board is closed. The tilting table should open to a right angle so that the camera may look vertically down when photographing tiny plants.

FIGURE 2.
The Half-plate Field Camera.

Another essential is that the whole camera should slide backward and forward on the tilting board. Suppose, for example, that we are photographing a plant, say natural size, with the camera looking obliquely down upon it, and have found a suitable view on our focussing screen, and proceed to focus. If we do this in the ordinary way, by backward or forward movement of the lens or focussing screen, the scale changes at once and we find that the flower has enlarged itself to, perhaps, twice its natural size before it is sharply in focus. If, on the other hand, we attempt to obtain correct definition by moving the camera and its stand backward and forward along the ground we either find that this is exceedingly difficult owing to the sloping bank on which the plant grows or to rocks or other obstructions, or else that, owing to the tilted position of the camera, the point of view entirely changes, for as we advance and recede, the object falls and rises on the focussing screen. It is much more convenient to focus by sliding the whole camera backward and forward on the tilting board and fixing it by a locking screw (C, Figures 2 and 3) before exposure. The tilting board on which my half-plate field camera slides has narrow brass strips on top which engage with similar brass strips screwed to the base of the camera. There is nothing striking about the little pieces of apparatus which I have had made to attach to the bases of my two field cameras, but as a diagram may perhaps be of service to some reader, I have thought best to include one with dimensions marked upon it. The half-plate size is here figured and the quarter-plate is very similar, except that the part of the tilting board which is nearest to the camera is formed of an aluminium plate instead of wood. Where, as very occasionally happens, the camera has to be directed upward instead of down, it is the easiest thing in the world to slide the instrument off the tilting base and reverse it so that the lens points upward, before replacing it.

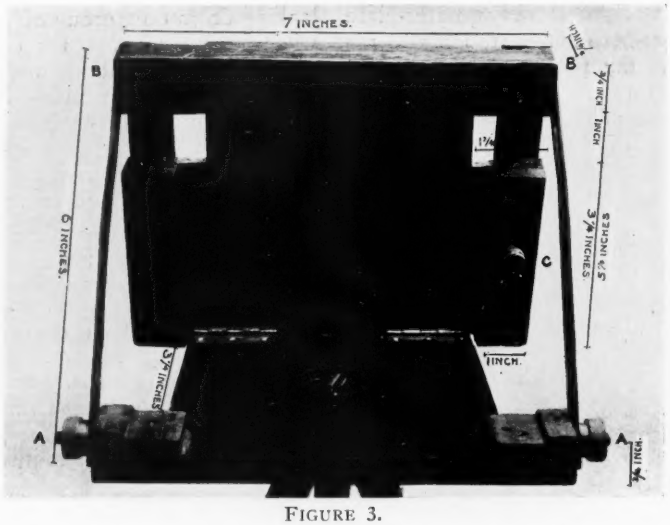


FIGURE 3.
The tilting base on which the Camera slides backwards and forwards.

THE STAND.

There can be no possible doubt that the telescopic is by far the most convenient type of stand for work in the field. It is easily carried and adjusted, and one of the better types with six or seven sections to each leg permits of the close approximation of the camera to the ground in photographing small plants. It is rigid enough even with a half plate camera, and is very rarely used fully extended.

Where there has been a strong wind blowing I have sometimes increased the weight, and therefore the rigidity, of my whole apparatus by placing a few large stones, wherever I could find room for them on the camera base. And sometimes where the camera and stand are much tilted, a few stones piled around that leg which has a tendency to rise will make the whole thing much firmer. If you are likely to use your camera-stand more than once, get a brass or steel one and strenuously avoid those made of aluminium.

THE LENS.

Turning next to the question of the lens I can again only give you my own limited experience. I have tried most makes but have got rid of all my lenses, except a Zeiss Tessar, which I use for everything. It is a delightful lens, and of especial value in autochrome work. It is certainly the best I have tried, though it is quite likely that there are others just as good. The right thing to do is clearly to try the lens you have and wait to get another till you are quite certain that your present one is deficient. I prefer a rather short focus lens, for then one can photograph an object natural size with the camera somewhat less than doubly extended, and complete double extension gives a slight magnification. Besides, it is often easier to pitch one's camera quite close to a plant than some little distance away, particularly in rocky places. There is no advantage in a wide aperture lens for plant photography. One working at F 6·5 or F 8 is quite good enough, and I never remember photographing a plant with a larger stop than F 8. Much more often one has to stop down to F 24 or 32 to obtain sufficient depth of focus. Occasionally in the field, and not infrequently in the studio, it may be desirable to photograph a plant or flower larger than natural size. This can be managed with the help of a triple extension camera, but rigidity is almost invariably lost with the greater degrees of extension, and it is much more convenient to increase the power of the lens by the addition of an ordinary convex objective. I use a simple convex lens placed in front of my camera lens. It is a corrected lens, being made up of two glasses cemented together, and is really the objective bought with a cheap quarter-plate camera. With it I am able to obtain any magnification up to six diameters. Beautiful autochromes as well as ordinary photographs can thus be obtained.

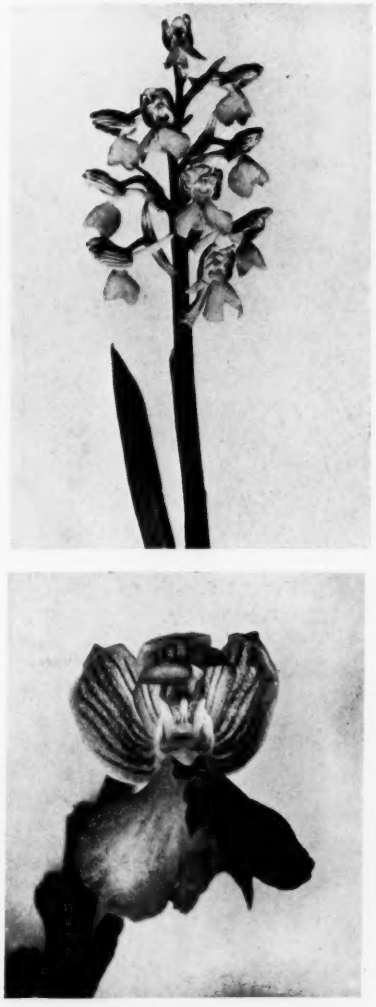


FIGURE 4.

The Green-winged Meadow Orchis (*Orchis Morio*). Photographed natural size and magnified four diameters.

PLATES.

For all ordinary work plates are much to be preferred to films. Backed plates should always be used, and a colour sensitive plate is essential. Undoubtedly the very best results are obtained with such a plate as the Panchromatic, but these are perhaps a little troublesome to develop, and quite satisfactory pictures can be taken on any of the ordinary colour sensitive plates. I have used Barnet Chromatics for several years, and have no reason to change. There is no point in selecting an excessively rapid plate, For blue, red or orange flowers a colour screen is, of course, necessary, but it has to be remembered that the use of a colour screen, even of the palest tint, doubles or quadruples the exposure, and makes the struggle with the worst enemy of the plant photographer—wind—all the keener. Not infrequently, therefore, the colour screen will be dispensed with, and a fairly satisfactory result obtained nevertheless. Occasionally also a special point in the picture can be emphasised, or made to stand out more clearly by intentionally over- or under-correcting the colour values. For instance, the yellow stamens of a white flower are more distinctly seen when no light filter is used, but a yellow flower will stand out best against grey rock if the colour values are slightly over-corrected. Sometimes the same result can be even better obtained by the use of a filter of red, blue, or green, or some other intermediate tint, or by making part of the exposure with one filter and part with another. I have tried this with success, but have generally found that it requires too much consideration in planning and too much care in carrying out to be of much practical use in the field.

COLOUR PHOTOGRAPHY.

But to obtain the very best results it is necessary to photograph plants in their natural colours. Nothing can exceed the beauty and charm of a flowering plant growing in its natural home and

photographed in its natural colours. Those who have once started colour work will never willingly return to the old monochrome. For myself, I can only speak of the autochrome process, but I have found this so perfect that I want nothing better. And it is really simpler than ordinary photography. A single exposure is alone required and the photograph can be finished in a quarter of an hour. With the help of a meter to calculate the exact exposure I find that I hardly ever spoil an autochrome plate except as the result of some technical error in the arrangement of the plants or on account of wind.

FIGURE 5.

The Wood Pink (*Dianthus sylvestris*). To show the effect of a natural background out of focus.

SELECTION OF SUBJECT.

It is difficult to give any useful hints as to the selection of the subject to photograph, for different people have very different ideas as to the effect they desire to obtain. With some a pleasing and natural picture is the chief aim, but others try to combine with this a botanically correct portrait of a plant or part of a plant, arranged to display its chief characteristics, such as buds, leaves, fruits, and so on. Generally, it may be said that the best results will only be obtained by those who know at least something of the subject they are trying to photograph. The individual, for instance, however proficient he may be as a photographer, who carefully arranges buttercup leaves among a group of poppies, where the foliage appears a little deficient, will not obtain a satisfactory picture. Not infrequently a small group of plants looks nicer than a single specimen, and wherever possible, it is wiser to select something compact and not very large, rather than a straggling mass. How far "faking" is permissible is a moot point. A little judicious weeding immediately around the plant to be photographed often makes it stand out much more clearly, and the same result is sometimes obtained by pushing away and pressing down the other plants which surround it. It is generally desirable also to remove any foreign plants that are growing among the group selected and sometimes the careful removal of a few dead or faded leaves, or even flowers, seems to do good. Where we find a rather straggling group of flowers with considerable depth of focus it is, I think, sometimes permissible to place a stone behind them in such a position that it cannot be seen from the front, so as to throw forward the flowers at the back and bring them more in line with the remainder.

Whether anything further is ever to be thought of is very uncertain. Whether, for instance, one or two buds should be added to a plant which is well proportioned and otherwise makes a pleasing picture but is deficient in this particular. Certainly, if Nature is to be assisted in any way, it needs to be done most carefully. Moreover, if there is the slightest breeze it will be often found that while the plant as a whole returns to its former position in the intervals, the additions do not, and a spoilt plate results. Further, where the exposures are long, as in colour work, what may be described as "fading fog" has to be reckoned with. Where the connection between the branch or flower and its root is severed, fading takes place and in plants growing in moist places this may be so rapid as to entirely spoil the picture after an exposure of five minutes. Had I not had

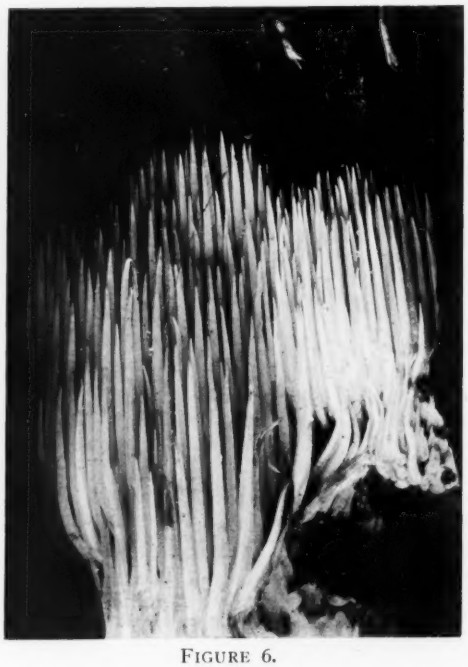


FIGURE 6.

A rare Fungus (*Hydrium crinaceum*). Photographed in a hollow tree on a foggy November day, in pouring rain, and given 15 minutes' exposure at F 11.

one or two unfortunate experiences in this way I should not have believed it possible.

BACKGROUNDS.

Although I have repeatedly made the attempt, I have never been able to produce a satisfactory result by using an artificial background. I have tried sheets of paper of various tints, supported in various ways or kept in movement by an assistant. Even where the motion does not extend to the plant, as very easily happens, the result is, in my experience, never satisfactory. Unquestionably the best background is the natural one, which, however, can be slightly modified where necessary by the removal of anything which will too prominently strike the eye, as for instance, a single large stone or a very noticeable plant of a different species. Plants of the same species, perhaps a little out of focus, seem to me rather to improve the general effect. In colour work special care must be taken of this point. A bright yellow buttercup, even if rather blurred in outline, behind a group of blue forget-me-nots catches the eye, and directs attention to itself more than to the subject of the picture. To my mind by far the best result, both pictorially and diagramatically, is obtained by the use of a natural background rather out of focus. There are three points to be borne in mind in obtaining this desired result. With the camera looking down obliquely at the plant, and the swing-back used as described in the early part of this article, the background is almost certain to be indistinct. Where the plants to be photographed are growing amongst others, the immediately surrounding vegetation, and especially that behind them may be pushed aside with the hand or even pressed down with the foot. And lastly, by very careful focussing and the use of the largest possible stop consistent with obtaining the required depth of focus, an indistinct background is obtained. In plant portraiture, no less than in human, the most artistic results are obtained by a somewhat indefinite background.

WIND.

In connection with field-work the greatest enemy of the plant photographer is wind. However calm it may appear, there are very few occasions, except soon after dawn and just before sunset, when vegetation is absolutely at rest. Of course, tall flimsy things like sedges and grasses are most affected, and short solid things like toadstools feel it least or not at all, but there are really very few occasions in ordinary field work when the wind has not to be considered. This will be the more evident when it is remembered that the exposures in plant photography are generally long, as a small stop has to be used. Frequently, for instance, I have had to give four to five minutes on a dull day with the ordinary plates, and five to ten minutes exposure is quite the rule, even at noon in the middle of the summer, with autochromes. The simplest method of obviating the effect of wind is to make one's exposure a few seconds at a time while the plants are quiet, for where Nature has not been assisted we can safely trust our sitters to return to exactly the same positions between the gusts. One must not necessarily conclude that a photograph will be entirely useless because there has been a certain amount of movement during some part of an exposure. Even where failure seems assured, it is just as well to develop, and sometimes the result will be an agreeable surprise. As a direct shield from the wind an umbrella or sunshade, preferably of a light colour, is exceedingly useful. A very little ingenuity in the placing of the camera and umbrella is sufficient to ensure that the latter does not appear in the photograph. One or more long-suffering friends who are capable of remaining in one position for several minutes, particularly if wearing overcoats or full skirts at the time, are also much to be desired. But as these aids, however desirable, are not always to be had, the plant photographer is advised to provide himself with what may be termed a "wind screen." A simple and useful form may be made as follows. Obtain a piece of stout white calico, six or eight feet long by fourteen inches wide and half-a-dozen fifteen-inch steel knitting needles. Roughen each knitting needle near one end by twisting some thin wire around it and soldering it to the knitting needle. Get someone to stitch four pieces of tape each fourteen inches long at equal distances along the strip of calico and one at each end, slip in the knitting needles and sew them firmly in place near one end so that the other end projects an inch. The apparatus is now complete. It is arranged on three sides of the plant with the camera lens looking over the middle of the enclosure and the whole thing strongly suggests a "coco-nut shy" on a small scale. It is wise to put the camera into position and roughly focus the plant before putting up the enclosure. Where a taller screen is used, it is desirable to have a slit cut in the calico near its middle, (with some hooks and eyes to close it if you like), through which the camera lens can be made to project. The only objection to such a screen that I know of is that it cuts off a certain amount of side light, and can hardly be used to completely surround the object, unless the camera is looking down on it more or less obliquely. Less light is cut off than might be expected, for the white calico reflects a good deal and is sometimes useful for this reason alone when there are heavy shadows. A more complete enclosure can be made by using a transparent material. Sheets of transparent celluloid about thirty-six inches by twenty can be obtained at any large photographic dealers for eighteenpence or thereabouts. It is easy to cement two or more of these together with collodion, which can be bought at any chemist's, allowing an overlap of half-an-inch. Strips of broad tape to enclose the steel wire standards can easily be cemented to the celluloid sheets with the same material, As the collodion softens the sheets it is best to let them dry between a couple of boards. A group of plants can be entirely surrounded by a screen of this sort, for a very pleasing effect is

XUM

obtained by photographing the natural background through a celluloid sheet. Or a combination of the calico and celluloid screens is often quite successful. I generally carry a couple of spare sheets of celluloid and a dozen tie-clips, and with these it is quite easy to roof in the little enclosure, and effectively prevent any movement of any but the most fragile of plants. In calculating the exposure, it is necessary to remember that an appreciable amount of light is absorbed by the celluloid.

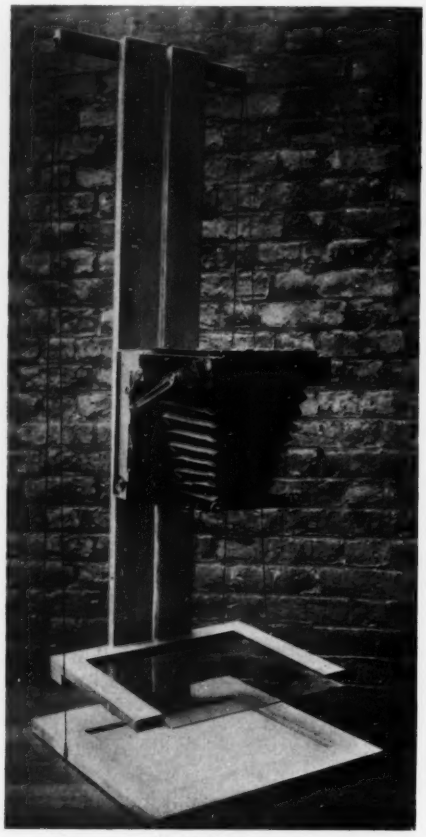


FIGURE 7.
The Studio Camera.

LIGHTING.

People often remark how nicely the lighting of my photographs is arranged. But I am hardly ever conscious of giving the matter any consideration at all. Certainly the calico wind screen set rather obliquely does reflect up a good deal of light. Occasionally, where there are very deep shadows, a piece of newspaper lying on the ground just in front of the plant, but so arranged that it does not appear in the picture, may also be useful. But generally speaking, seeing that our object is to obtain as natural-looking pictures as possible, the less we trouble about the lighting of our subject the closer to Nature will our result prove. Photographs should never be taken in direct sunlight, for the deep shadows are devoid of detail and mostly unsightly. Always stand between the plant and the sun or use an umbrella.

EXPOSURE.

If you want to economise time and money, buy an exposure meter and use it. Use it at first in every case, for the difference of light value in a wood or beneath a hedge, compared with that in an open field is very considerable. Place the exposure meter as near as possible to the object to be photographed, and read off the exposure, allowing for the size of the stop and the variety of plate used. Multiply this by three if you are photographing about half natural size, by four if you are photographing, roughly, natural size, and by six if you are taking the plant a little bit enlarged with a much extended camera, but without any extra front lens. The reason for this increased exposure is that the size of the stop, as indicated on the lens, is only correct when distant objects are photographed, and when the camera is extended as in photographing an object about natural size and the distance of the plate from the lens is approximately doubled, the number representing the size of the aperture is in reality double that indicated. For instance, if we appear to be using F32 while photographing an object natural size we are in reality using F64, and as everyone knows this aperture will require four times the exposure of F32 for the same conditions of light. Unless the plant photographed is absolutely free from deep shadows, it is wise to multiply by two again. There are noteworthy exceptions, but it is a general rule that most plate makers put a very liberal estimate on the speed of the plates they manufacture, and if thirty per cent. or so is deducted from the speed given, the exposure calculated will, in most cases, be the more correct. In all cases, if we err at all, it is better to err on the side of over-exposure. Where the test paper of the exposure meter takes several minutes to change colour, as in studio work, or outside in very dull weather, it is often convenient to expose at the same time that the exposure is being calculated. I use a Wynne meter and as soon as I have started exposing I set it up so that it is receiving the same light as my subject, but is just outside the picture. Using plates of speed 100 and photographing natural size, I find that when the test paper has changed to the lighter colour my exposure is correct for a 16 stop (which is really 32 as the camera is doubly extended), and when the colour has changed to the deeper tint I am all right for F32 (really 64). In autochrome work the exposure is estimated very simply. Using the Wynne meter, we know that the time taken for the test paper to reach the darker tint is the correct exposure for a landscape at F11. For photographs of objects taken approximately natural size, we multiply by four, and if there are any shadows at all by two again. Allowance for every stop other than F11 is made according to the ordinary rules.

STUDIO WORK.

In conclusion, may I add one or two hints as to studio work. My experience in this part of the subject has, however, been much more limited. The accompanying photograph of the apparatus I use will explain itself. It consists of a base with a slotted wooden standard some four feet long. Moving up and down on the standard, but kept in

line by pieces of wood that fit into the slot, are a half-plate camera mounted on a box, and a carrier to hold a 12-in. by 10-in. sheet of glass. The carrier is open in front to avoid any shadows on the background placed below, and both carrier and camera are clamped in position on the standard by thumb screws. The tense copper wires greatly increase the rigidity of the whole thing. The apparatus is used in an ordinary room close to the window, or preferably in a bay window, porch, or greenhouse, or even outside. The plant to be photographed rests on the glass plate, and about three or four inches below it, to avoid shadows, is placed a sheet of white or grey cardboard. A very dark or black background is in this situation unsatisfactory, for the glass plate then becomes a looking glass and a double image of the plant is seen in the photograph. Where a black background is required the plant rests directly on a sheet of dull black paper which is supported on the glass plate. For colour work an interesting background is often made by a sheet of white cardboard with one or several layers of "chiffon" of different tints laid on it. Given a dozen or more pieces of "chiffon," a thin silky material, dyed half a dozen different colours, almost any tint can be built up. If the background is some three or four inches away it will be sufficiently out of focus to prevent any slight irregularities in the material appearing in the photograph. This point should be tested before exposure by a careful inspection after the lens has been stopped down sufficiently. Of course, it is by no means always necessary or desirable to lay the plant down to photograph it. Often much more natural results are obtainable if the plant is held erect in a vase of water, being sure that the vase does not appear, with the background sufficiently far away from it to be thoroughly out of focus. Even in this position a sheet of glass immediately behind is often of value, for it limits the depth of focus of the picture and gives support to flimsy plants. In photographing plants we must remember that we are dealing with living things which actually move, especially when any change takes places in the equilibrium of their water-vascular system. Hence it is unwise to pick flowers on a hot summer day, put them in a vase of water and immediately give them a prolonged exposure. Rather should they be left in water for at least two hours so that the cells of the plant may accustom themselves to an abundant water supply. Again, when flowers are taken out of water and put into position to be photographed it is just as well to cover the cut stalk, if it does not appear in the photograph, with a small piece of moistened cotton-wool to prevent "fading fog." Where the light is poor both in the studio, and the field, focussing is greatly assisted by placing a small scrap of printed paper close to and in the same plane as the principal object to be photographed, of course removing it before the exposure is made.

SOLAR DISTURBANCES DURING AUGUST, 1911.

By FRANK C. DENNETT.

DURING August the disc appeared to be quite free from disturbance on the 1st, 4th and 26th until 31st, whilst only faculae were seen on the 2nd, 3rd and 18th until 25th. The longitude of the central meridian at noon on August 1st was 15° 29′.

No. 32.—The most conspicuous outbreak of the month, first seen within the limb on the 5th. The umbra of the large spot was bridged on the 7th, and had an extension eastwards, with a small companion following. During the 8th and 9th other spotlets formed, and changed, indicating considerable activity, and the inner border of the penumbra of the large spot was bright from the 7th until the 10th. Only a minute pore remained as its solitary companion on the 11th, when the spot had dwindled considerably. On the 13th, there were two closely placed umbrae, and on the morning of the 14th, when last seen, only one. The maximum diameter of the spot was over ten thousand miles, and the length of the group over forty thousand miles.

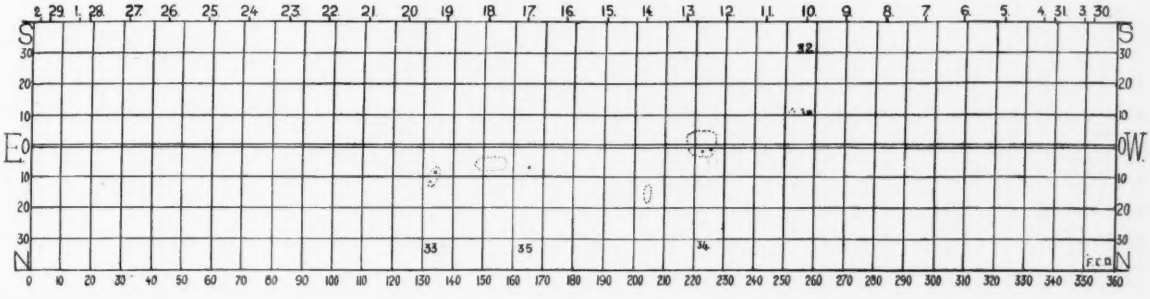
No. 33.—Two pores amid brilliant faculae had come round the limb on the 13th, the rear one being 2° farther north, and a similar distance eastward of the leader. They died away on the 15th.

No. 34.—A pair of pores three degrees apart had broken out on the 15th, next day the rear one had closed up, but the area appeared disturbed, and on the 17th, when last seen, the pore appeared cut in half by a bridge.

No. 35.—A solitary pore only seen on the 16th. There may be a very small error in its position. The dotted areas upon the chart indicate the positions of faculic areas; that around No. 34 being observed on the 7th and 8th; that at 205° from the 8th until the 10th. The group around longitude 153° on the 13th. Not the least interesting faculic disturbance, however, was a bright group on the 19th, in 60° south latitude near longitude 67°, seen until the 23rd, though its brilliance had decreased. The general granulation of the disc appeared coarse over the south-eastern quadrant on the 27th.

Our chart is constructed from combined observations of Messrs. John McHarg, E. E. Peacock, and F. C. Dennett.

DAY OF AUGUST, 1911.



THE FACE OF THE SKY FOR OCTOBER.

By W. SHACKLETON, F.R.A.S., A.R.C.Sc.

THE SUN.—On the 1st the Sun rises at 6.0 and sets at 5.40; on the 31st he rises at 6.52 and sets at 4.36. Conspicuous Sun-spots and faculae are not to be expected at this phase of the eleven-yearly cycle, but smaller displays may occasionally be visible. The positions of the Sun's axis, centre of the disc, and heliographic longitude of the centre are given in the following table:

Date.	Axis inclined from N. point.	Centre of Disc N. of Sun's Equator.	Heliographic Longitude of Centre of Disc.
Oct. 3	26° 13′E	6° 35′	263° 19′
,, 8 ...	26° 25′E	5° 18′	197° 20′
,, 13 ...	26° 25′E	5° 58′	131° 23′
,, 18 ..	26° 14′E	5° 35′	65° 26′
,, 23 ...	25° 52′E	5° 10′	359° 29′
,, 28 ...	25° 19′E	4° 43′	293° 33′
Nov. 2 ...	24° 33′E	4° 13′	227° 37′
,, 7 ...	23° 35′E	3° 41′	161° 41′

An Annular Eclipse of the Sun occurs on the 22nd, it is invisible in this country, but visible as a partial eclipse in India and Australia.

THE MOON:—

Date.	Phases.	H. M.
Oct. 8 ...	○ Full Moon	4 11 a.m.
,, 14 ...	☾ Last Quarter	11 46 p.m.
,, 22 ...	● New Moon	4 9 a.m.
,, 30 ...	☽ First Quarter	6 41 a.m.
Nov. 6 ...	○ Full Moon	3 48 p.m.
Oct. 12 ...	Perigee	6 36 a.m.
,, 27 ...	Apogee	10 36 p.m.

OCCULTATIONS.—The following table gives particulars of the principal occultations visible from Greenwich:—

Date.	Star's Name	Magnitude.	Disappearance.		Reappearance.	
			Mean Time.	Angle from N. point. E.	Mean Time.	Angle from N. point. E.
Oct. 3	37 Capricorni ...	5·7	p.m. 11 48	355°	a.m. 0.16	306°
,, 6	ψ^1 Aquarii ...	4·5	a.m. 2.16	353°	a.m. 2.43	302°
,, 6	ψ^2 Aquarii ...	4·6	a.m. 2 49	86°	a.m. —	—
,, 13	B.A.C 1754 ..	5·7	a.m. 1.31	110°	a.m. 2.31	226°
,, 28	B.A.C. 6628 ...	5·9	p.m. 6.18	26°	p.m. 7.10	305°

THE PLANETS.

MERCURY:—

Date.	Right Ascension.	Declination.
	h. m.	
Sept. 29 ...	11 19	N 6° 6′
Oct. 9 ..	12 20	S 0° 7′
,, 19 ...	13 23	S 7° 32′
,, 29 ...	14 25	S 14° 20′
Nov. 8 ...	15 27	S 19° 53′

Mercury is a morning star until the 23rd, when he will be in superior conjunction with the Sun. The planet may possibly be observable during the first week of the month, when he rises, almost due East, more than an hour before the Sun.

VENUS:—

Date.	Right Ascension.	Declination.
	h. m.	
Sept. 29 ...	10 52	S 0° 26′
Oct. 9 ...	10 52	N 1° 50′
,, 19 ...	11 5	N 2° 38′
,, 29 ...	11 28	N 2° 3′
Nov. 8 ...	11 59	N 0° 20′

Venus is a morning star throughout the month, rising, almost due East, at 3.10 a.m., on the 15th. The planet will be at its greatest brilliancy on the 22nd, and its angular distance from the Sun will continue to increase until it reaches greatest westerly elongation, on November 26th.

MARS:—

Date.	Right Ascension.	Declination.
	h. m.	
Sept. 29 ..	4 28	N 20° 28′
Oct. 9 ...	4 36	N 21° 3′
,, 19 ...	4 38	N 21° 30′
,, 29 ...	4 34	N 21° 49′
Nov. 8 ...	4 23	N 21° 58′

Mars is now approaching opposition (November 25th), and will be well placed for observation during the later hours of the evening. The planet rises N.E. by E., about eight p.m., at the beginning, and about six p.m. towards the end, of the month. Its apparent diameter increases during the month from 14″·1 to 17″·5. The planet will be easily identified if looked for about five degrees to the North of Aldebaran. The South pole of the planet is turned towards the earth.

JUPITER:—

Date.	Right Ascension.	Declination.
	h. m.	
Sept. 29 ...	14 49	S 15° 23′
Oct. 9 ...	14 57	S 15° 59′
,, 19 ...	15 5	S 16° 35′
,, 29 ...	15 14	S 17° 11′
Nov. 8 ...	15 23	S 17° 45′

Jupiter is nominally an evening star throughout the month, but he is very low down in the South-Western sky at sunset, and as he sets about an hour after the sun, he can only be observed with difficulty.

The configuration of the Satellites as seen in an inverting telescope, and observing at six p.m., are as follows:—

Day.	West.	East.	Day.	West.	East.
1	3 ○ 214		11	42 ○ 3 1●	
2	31 ○ 24		12	41 ○ 23	
3	32 ⊙ 4		13	4 ○ 123	
4	2 ○ 134		14	421 ○ 3	
5	1 ○ 234		15	3¾ ○ 1	
6	○ 2143		16	31 ○ 42	
7	214 ○ 3		17	32 ○ 14	
8	43 ○ 1 2●		18	2⅓ ○ 4	
9	431 ○ 2		19	1 ○ 234	
10	432 ○ 1		20	○ 1234	

The circle (○) represents Jupiter; ⊙ signifies that the Satellite is on the disc; ● signifies that the Satellite is behind the disc or in the shadow. The numbers are the numbers of the Satellites.

SATURN:—

Date.	Right Ascension.	Declination.
	h. m.	
Oct. 1 ...	3 11	N 15° 12′
,, 16 ...	3 8	14° 56′
,, 31 ...	3 3	N 14° 37′

Saturn may now be conveniently observed during the evening, as he rises, in the E.N.E., at 7.8 p.m. on the 1st, and at 5.6 p.m. on the 31st. The planet is a conspicuous object, some distance to the west of Aldebaran and Mars, and cannot be mistaken. The rings are well open, the outer major and minor axes being respectively 47″ and 17″, and the inclination of the plane of the ring to our line of vision being 21°. The Southern pole of the planet is presented towards the earth. The planet has eight satellites: of these, Titan (magnitude 8·5) can be observed with a good objective of two inches aperture, Iapetus (magnitude 9–12) may be seen at westerly elongation with a telescope of three inches aperture, which is also sufficient to show Rhea (magnitude 9.5) and Tethys (magnitude 10), whilst Dione (magnitude 10·5) requires an aperture of four inches.

The three other satellites require larger telescopes since their magnitude is less than 12.

URANUS:—

Date.	Right Ascension.	Declination.
	h. m. s.	
Oct. 1 ...	19 49 57	S 21° 36′ 39″
Nov. 1 ...	19 51 10	S 21° 32′ 48″

Uranus, in Sagittarius, can only be observed in the early evening during the present month, and is too low in the sky to be well seen. The planet sets about 11.14 p.m. on the first, and about 9.17 p.m. on the thirty-first. It can be distinguished from neighbouring stars by its small greenish disc of 3½″ diameters, if viewed with sufficient magnifying power. After October 6th, when the planet is stationary, the motion will be direct, or easterly.

NEPTUNE:—

Date.	Right Ascension.	Declination.
	h. m. s.	
Oct. 1 ...	7 41 26	N 20° 49′ 23″
Nov. 1 ...	7 42 15	N 20° 47′ 7″

Neptune is not yet very conveniently placed for observation, as he does not rise before 11 p.m. at the beginning of the month, nor before 9 p.m. at the end. The planet is located in Gemini, nearly midway between 68 Geminorum and ψ^2 Cancri. The motion is direct, or easterly, until the 28th, when the planet is stationary.

METEORS:—

Date.	Radiant.		—
	R.A.	Dec.	
Oct. 2 ...	230°	N. 52°	Slow, bright.
,, 4 ...	310°	N. 79°	Slowish.
,, 8 ...	77°	N. 31°	Swift. streaks.
,, 8-14 ..	45°	N. 58°	Small, short.
,, 14 ...	133°	N. 68°	Rather swift.
,, 15 ...	31°	N 9°	Slow.
,, 18-20...	92°	N. 15°	Swift, streaks.
,, 23 ...	100°	N. 13°	Swift, streaks.
,, 29 ...	109	N 23°	Very swift.

The principal shower is that having its radiant point near ν Orionis, and hence known as the Orionid shower; the maximum display is from the 18th to the 20th.

ALGOL.—Observable minima of Algol occur on the 12th at ten p.m., and on the 15th at seven p.m. The period is $2^d\ 20^h\ 49^m$.

TELESCOPIC OBJECTS:—

DOUBLE STARS.—γ Arietis, $1^h\ 48^m$, N. 18° 48′, magnitudes 4·2, 4·4; separation 8″·8. Easy double, with a power of 30; the first double star telescopically observed.

γ Andromedae $1^h\ 58^m$, N. 41° 51′, magnitudes 2·1, 4·9; separation 10″. The brighter component is intensely yellow, whilst the other is greenish-blue. The fainter star is a binary, the components of which are now less than half a second apart.

NEBULAE.—The Great Nebula in Andromeda 31M, easily visible to the naked eye, and readily distinguished by the aid of an opera glass, in the neighbourhood of ν Andromedae. Seen with a three- or four-inch telescope, it appears as an extended oval with a bright nucleus, and has often been mistaken for a comet. Spectroscopic observations suggest that it is built up of a vast number of stars.

(32M) Nebula about 2° to the South of the Great Andromeda Nebula. It is fairly round and appears like a star out of focus.

(18H) lies about the same distance North of the great Andromeda Nebula that 32M does South; it is faint, but large and elliptical.

COMETS.—Observers who possess a pocket spectroscope, or its equivalent, will find it of interest to examine the spectrum of Comet Brooks, even if the telescope has only an aperture of two or three inches. The three typical bands of cometary spectra, in the yellow green, green, and blue, were easily visible under these conditions at the time of writing (September 16th). The slit should first be placed at the focus of the telescope by observations of a bright star, the spectrum of which should appear as a narrow streak when the adjustment is made. The image of the comet may then be brought on the slit with the aid of the finder.

Comet Brooks (1911 *c*) is visible to the naked eye as a third magnitude star, but with a pair of binoculars the nebulosity round the nucleus may easily be seen. The comet is moving on the confines of Ursa Major and Botes towards Leo and at the beginning of the month is situated about 5° S of η and Ursa Majoris, the star at the tip of the Bear's tail.

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REVIEWS.

CHEMISTRY.

New Ideas on Inorganic Chemistry.—By DR. A. WERNER. Translated by E. P. HEDLEY, Ph.D. 268 pages. 9-in. × 6-in.

(Longmans, Green and Co., Price 7/6 net.)

This is among the most valuable contributions to the science of Chemistry which have been made of recent years. The first edition was published in Germany in 1905, and within three years a second edition was required. The present book is the translation, with some additions and corrections, of this second edition.

It deals, in the main, with the problem of the valency of the elements as shown in their different compounds, and while outlining the various theories that have been put forward, attempts to weave them into a consistent fabric, and discusses their relationship to the observed facts.

Although the systematic classification of inorganic compounds does not as yet rest upon so stable a basis as that of organic compounds, indications are not wanting that before long such a scheme may be devised. In fact this book goes a long way in this direction.

Both as a critical history of the doctrines of valency and a guide to unexplored fields, it should meet with a welcome from all chemists, and in particular from those whose work involves a consideration of the structural constitution of inorganic compounds. The book is excellently translated, though there are a few grammatical slips, and is clearly printed and arranged; but although there is a full table of contents at the beginning of the book, the absence of an index is a blemish. Its use as a handbook to research would also be greatly increased by repeating the references given at the foot of each page in a classified bibliography.

C. A. M.

Inorganic Chemistry,.—By F. STANLEY KIPPING, D.Sc., F.R.S., and W. H. PERKIN, D.Sc., F.R.S. 751 pages. 120 illustrations. 7½-in. × 5¼-in.

(W. & R. Chambers. Price 7/6.)

So great is now the number of elementary text-books of Chemistry that any fresh addition to them needs to justify its existence by novelty of treatment or arrangement. In the present case there is undoubtedly such justification, the subject matter being so arranged as to avoid some of the pitfalls in the way of the beginner.

All who have had experience in teaching will recall the difficulty of convincing a young student of the reality of an invisible body, and of making him grasp the fact that a salt in solution has as real an existence as an insoluble compound. This was summarised by Professor Vernon Harcourt in his phrase, that "a precipitate is too often an object of superstitious veneration."

To obviate this difficulty the authors of this book have wisely postponed the consideration of the gaseous elements, with which most text-books start, until such time as the student shall have acquired a practical acquaintance with the reaction of common salts.

The first part covers the ground needed for the London Matriculation examination, while in the second part chemical and physical changes are dealt with more fully, and sections upon the determination of molecular weights, ionic dissociation, spectrum analysis, and radioactivity are included.

In this part also comes the systematic account of the elements. The interest of the student is likely to be maintained by the way in which metallic and non-metallic elements have not been isolated from one another.

Throughout the book, experiment goes hand-in-hand with theory, and although the utilitarian end of examinations is not lost sight of, it is not unduly emphasised.

We can, therefore, heartily recommend the book to any beginner who wishes to study Chemistry without the necessity of following set courses of lessons.

C. A. M.

GEOGRAPHY.

Modern Geography.—By MARION I. NEWBIGIN, D.Sc. 256 pages. 13 illustrations. 7-in. × 4-in.

(Williams & Norgate. Price 1/- net.)

This little book forms part of the Home University Library, and is an excellent compendium of the different subjects brought into relation under the head of geography. The standpoint is "frankly anthropological," geography being considered as the study of the earth in relation to its inhabitants, especially man. The chapter headings, however, raise the doubt, at least in the mind of the reviewer, whether geography is, after all, a unit of science like chemistry or zoölogy. For instance, two of the chapters are geological, others are botanical, zoölogical or ethnographical. Is not geography, therefore, rather the application of many sciences to the description of the earth in relation to its inhabitants? Be that as it may, we have read Miss Newbigin's work with great pleasure, and believe that it will give similar pleasure to that section of the public which desires popular accounts by competent specialists of the latest developments in knowledge. A note on the literature and a good index is provided.

G. W. T.

GEOLOGY.

Characteristics of Existing Glaciers.—By W. H. HOBBS. 301 pages. 34 plates. 140 figures. 9-in. × 6-in.

(New York: The Macmillan Co. Price 13/6 net.)

This important and authoritative work is by a distinguished American glacialist whose mind has not been unduly obsessed by the importance of the alpine type of glacier. Throughout the book emphasis is placed on the contrast between mountain glaciers—the alpine type—and continental glaciers, such as those which cover Greenland and the Antarctic Continent. Hitherto, despite the enormous disparity in size and shape, the practice has been to treat these types together as if they obeyed the same laws and accomplished the same work. This book takes the view that mountain and continental glaciers are different in kind rather than in degree. In accordance with this view, most space is allotted to the continental type as being by far the largest and most important masses of ice. The ice-caps covering small elevated areas, such as those of Iceland, are regarded as in some measure intermediate between the two types; but physiographically they are allied to the continental ice-sheets, and have few affinities with mountain glaciers.

Professor Hobbs is a convinced upholder of the excavating and eroding power of glaciers, in opposition to the school which claims that glaciers exercise a more or less protective influence on their beds. We think, however, that the author assigns too little weight to the maturely considered views of such authors as Bonney and Garwood as to the protective influence of glaciers. In regard to mountain glaciation, much importance is given to cirque-recession as one of the chief erosional methods of small bodies of ice, in strong contrast to continental ice-masses, whose chief method of erosion is by abrasion of their floors.

One of the most useful features of the book is the way it summarises and collates the ice-observations of numerous

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recent Arctic and Antarctic expeditions, down to those of Peary and Shackleton.

The book is excellently and profusely illustrated. Each chapter is accompanied by a full list of references, and an adequate index is provided. We welcome it as an excellent reference work to modern views of glaciation, the literature of which is widely scattered, enormous in its extent, and to many workers rather inaccessible. G. W. T.

The History of Geology.—By H. B. WOODWARD, F.R.S., F.G.S. History of Science Series. 154 pages. 14 plates. 6½-in. × 5-in.

(Watts & Co. Price 1/- net.)

As a science, geology dates from the close of the eighteenth century, although many vague and curious notions as to the constitution and structure of the earth were current before this time. These ideas were originated by speculation about earthquakes, volcanoes, springs, landslips, and other natural phenomena. Mr. Woodward goes as far back as the philosophers of Greece and Rome, in his search after quotations which seem to prove that the germs of some modern geological ideas originated in very early times. After a chapter on these early notions, the author passes on to review the work of the founders of modern geology, Hutton, Werner, and their contemporaries, whose work made possible that "golden era" of geology, the giants of which were Sedgwick, Murchison, Lyell, Von Buch, and Elie de Beaumont. It is gratifying to note the predominance of British names in the history of geology. So much has the pioneer work of British geologists impressed itself on the science that the common local stratigraphical terms, such as Lias, Devonian, Silurian, and so on, coined in this country, are now used all over the world. In regard to petrology we miss a reference to the recent work of Whitman Cross on the history of that branch of the science. Mr. Woodward is to be congratulated on this thoroughly readable and useful little book, which supplies an undoubted want in the literature of geology. It is illustrated by fourteen excellent portraits of famous geologists, including Miss Etheldred Benett (1776—1845), the first lady to distinguish herself by a systematic study of the science. G. W. T.

METEORIC PHENOMENA OF SEPTEMBER 2nd, 1911.

By W. F. DENNING, F.R.A.S.

THERE were some beautiful fireballs observed on September 2nd, and the date was already known as one on which these objects are apt to appear with unusual abundance.

In the sunshine of the afternoon, at 3.45 p.m., a splendid meteor was seen from various stations in Cornwall and Devon. Situated beyond the Bristol Channel, it could not be well observed from N.E. counties. Observed from Newquay, it was described as being like an elongated or pear-shaped electric bulb with a tail, travelling at great speed and emitting a brilliant white light.

At Launceston the meteor fell in the north, being directed from the west, at an angle of about 45°.

At Redruth "a brilliant star with a tail" was observed running to the N.N.E.

At Polzeath it surprised some golf players, who noticed its brilliant flash of silver light in the sky. Its direction was from S. to N. At Barnstaple it was alluded to as a meteor of great lustre, travelling from S.W. to W. at fifty degrees above horizon.

At Fowey it was seen as "a brilliant kite with sparks issuing from the tail and travelling from N.N.W. to N.N.E." Unfortunately these and other accounts are not sufficiently exact—but it is hoped that descriptions will yet be forthcoming and allow the real path of this daylight fireball to be well determined.

On the same date, but when darkness had nearly closed in, and the stars were shining as brightly as they well could with the presence of a gibbous moon in the southern sky, another grand meteor appeared, and the number of its observers seem to have been legion. This time the locality favoured was transferred to the North Sea and Scotland, for the meteor took a long and rather slow flight over Berwick, Edinburgh, and Stirling, finally disappearing over Argyle when N. of Inverary.

The spectators of it were distributed over a wide area, for descriptions of its aspect and position have come from Leeds, Manchester and North Wales in the South, from Dungannon, Tyrone in the West, and from Rothes and Rothiemay in the North.

All classes of people saw it, from the untutored agricultural labourer to the cultured *savant*, and some of the reports are very good, though others are not without rather serious discordances.

The meteor was one of the finest kind, for at Edinburgh, Glasgow and other places not very far from its track its light burst with astonishing brilliancy over the sky and landscape, and some people mistook it at first for a very prolonged lightning flash, while others thought it due to the explosion of a monster rocket. The light of a nine-day old moon seemed pale and insignificant beside the splendour of the meteor when it momentarily shone at its best.

It is not feasible to refer to the individual observations. The statements as to colour differ but the nucleus appears to have been of an electric blue, while the tail following it was reddish-yellow.

I have compared about fifty observations of the object, and find that its height was from about eighty-eight to twenty-six miles, directed from E.S.E. to W.N.W., along a path of one hundred and ninety-six miles, traversed at a velocity of nineteen miles per second. It was a member of a well-known meteoric shower in Pisces at 348°+3°, which supplies many beautiful fireballs during the last half of August and first half of September.

Some of the observers did not witness the whole of the luminous course. Many of them only looked up to the heavens when the meteor's startling lustre attracted their attention, and after it had already completed a large section of its trajectory.

The meteor was probably the most brilliant object which passed over Scotland since the great Leonid fireball of November 16th, 1910, described in "KNOWLEDGE." for March, 1911, page 116.

The radiant South of the Square of Pegasus, in Pisces, has previously furnished many fine meteors, and the following is a summary of a few of the more interesting :—

Date.	Mag.	Radiant.
1900, Aug. 19	3× ♀ ...	346°± 0°
1901, „ 21	1st ...	341°+ 5°
1899, „ 24	½ ☽ ...	345°+14°
1899, Sep. 8	> ♀ ...	347°+ 3°
1875, „ 14	> ☽ ...	348°± 0°
1901, „ 14	♀ ...	345°+ 1°
1898, „ 17	1st ...	343°± 0°
1906, „ 27	♀ ...	345°+ 2°

This year I saw several small meteors early in September from this shower, but the fireball was too far north to be visible at Bristol.

We have had here in Bristol a magnificent summer for observing purposes. Between July 1st and September 22nd (eighty-four nights) there were only two nights on which the stars were invisible.

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"SWEEPINGS."

By FRED ENOCK, F.L.S.

AUGUST 22nd, 1911, will long be remembered by Mr. Chas. O. Waterhouse and myself as a "red letter day," for we had swept the grass and herbage in and about Richmond Park *so* often without capturing anything particular, though we have both swept many localities in the hope of a prize, and we have taken several firsts, as well as specials, offered to all who will enter the arena open to every one so inclined.

The day opened threateningly, the clouds looked as though they had a thunderstorm in hand, but it cleared off and bright sunshine appeared.

We swept our crossing backwards and forwards for a couple of hours without much luck, just a few of our favourite *Cosmocoma fumipennis* (females), the male of which we had searched for for many years. I captured my first female at Woking, in 1885, and have been looking for the male ever since. I intended to go on sweeping for another ten minutes. Mr. Waterhouse had gone on about a mile, when, on taking my seat to examine the contents of my net, I ran my eyes over the grass seeds, bits of sharp-pointed rushes, tumbling out the numerous spiders, when my eye was caught by the long filiform antennae of a Cosmocomid with hairy wings. My phial was ready to be popped over it, when a great fat spider intervened and I lost sight of my quarry—but found it again and succeeded in getting it into my phial, and corking it up. *Then* I saw that after twenty-five years "keepin' on," I had captured the male of *Cosmocoma fumipennis!*

FIGURE 1.
Elenchus tenuicornis, larval stage, $\frac{1}{120}$ of an inch long.

FIGURE 2.
Elenchus tenuicornis (female).

Thinking there might be another prize in my net, I soon had my lens in position, when I saw a tiny insect buzzing about in the net. I instantly thought—"Why! it's a *Stylops* or its relative *Halictophagus.*" As soon as the cork closed on it I confirmed this. My ten minutes was now up, but I could not leave without telling Mr. Waterhouse, so I hurried across in the direction he had taken, and as I neared the wood I shouted, "Waterhouse, I've got it!" "Waterhouse, I've got it!" At last I heard the response, "Is that you shouting, Enock. What have you got?" Then the two old boys camp-stooled together and revelled in examining my captures.

When I reached home my buzzing *Halictophagus* was dead and mounted as soon as possible.

I had turned and killed my other captures, among which were several Frog-hoppers, and close to one, an egg-like body, with black eyes, just one hundred and twentieth part of an inch long. Thinking it an egg containing a Mymarid, I put it under the quarter-inch lens, and immediately recognised it as the hexapod larva of one of the Strepsiptera, and no doubt, as I at first imagined, of *Halictophagus.* But on reference to Westwood's "Modern Classification of Insects," I identified my capture as *Elenchus tenuicornis* (Templeton), of which but one example had hitherto been recorded, over fifty years ago.

I am now searching for missing links in the life-history of this strange insect.

NOTES.

ASTRONOMY.

By A. C. D. Crommelin, B.A., D.Sc., F.R.A.S.

STELLAR PARALLAXES.—*The Astrophysical Journal* for July contains an interesting paper by Frank Schlesinger on the photographic determination of stellar parallaxes with the Yerkes' refractor. There has been a great advance in accuracy in recent years, and the probable error of determination is of the order 0″·02. One general result derived is the great distance of the helium stars; four fourth-magnitude stars of this type are of sensibly the same distance as the ninth-magnitude comparison stars. The following table gives the parallaxes deduced where they exceed 0″·1:—

Star.	Prop. Motion.	Parallax.
Struve 2398	2″·28	″·29
Groombr 34	2″·85	″·27
BD+56° 2783	0″·92	″·25
WB V 592	2″·23	″·19
Lal 25372	2″·33	″·15
Lal 46650	1″·40	″·15
Lal(F)1457,1458	1″·69	″·15
WB XVII 322	1″·36	″·14
μ Cassiop.	3″·75	″·11
b Aquilae	0″·96	″·10

Where the parallax star was much brighter than the comparison stars, its light was reduced by a rotating disc, to keep its image small and measurable. This plan worked very successfully. He estimates that the number of parallaxes that can be determined per annum with this telescope is equal to the number of fine nights, about thirteen plates being taken on each night, and thirteen of each star during the year.

COMETS.—The following revised elements of Comets 1911*b* (Kiess) and 1911*c* (Brooks) are by Dr. Kobold:—

Comet.	Kiess.	Brooks.
T in Berlin M.T....	1911, June 30·3093	1911, Oct. 27·7623
Omega	110° 33′ 50″ ...	152° 44′ 18″
Node	157° 26′ 21″ ...	293° 10′ 6″
Inclination... ...	148° 27′ 25″ ...	34° 0′ 3″
Equinox	1911·0	1911·0
Log q.	9·83565	9·69036

Both comets were evidently difficult objects to observe accurately, as there are large discordances which, in the case of Kiess, suggest that the orbit differs sensibly from a parabola. This comet is now too far South to be seen in England, and has also sunk to the tenth magnitude, but Brooks' will be a conspicuous naked-eye object in the evening sky early in October. It was half a magnitude fainter than the Andromeda nebula on August 29th, and its intrinsic brightness is likely to increase considerably as it approaches the Sun, so that it may reach the second magnitude.

Ephemeris for 11 p.m.:—

	R.A. H. M. S.	N.Dec.		R.A. H. M. S.	N.Dec.
Oct. 1...14	7 2	43° 10′	Oct. 9...13	19 56	32° 50′
,, 3...13	53 35	40° 44′	,, 11...13	10 46	30° 2′
,, 5...13	41 18	38° 11′	,, 13...13	2 34	27° 11′
,, 7...13	30 6	35° 33′	,, 15...12	55 22	24° 14′

On September 30th it is 2° South of λ Bootis, and forms a continuation of the tail of the Great Bear.

On October 4th it is 10° East of Cor Caroli (α Canum Ven.).

On October 12th it is near β Comae. On this day it is in conjunction with the Sun, 36° North of it; after this it may be best seen in the morning, though visible in the evening for a few nights longer.

ENCKE'S COMET.—M. Gonnessiat gives in *Astr. Nachr.* 4518, particulars of his observations of Encke's Comet on July 31st and August 1st. Its finding was the result of patient search, and it could only be seen on these two mornings, and then only for a few minutes between its rising and the dawn. On August 1st it was thought to be of magnitude seven-and-a-half.

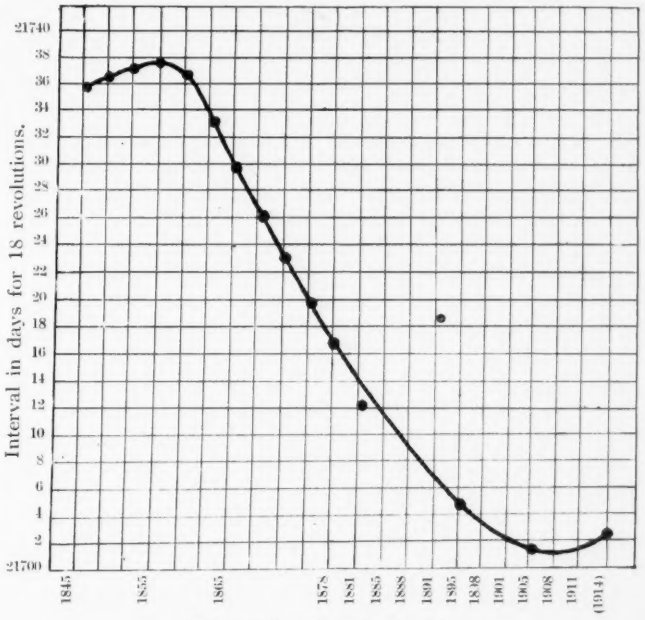

FIGURE 1. Encke's Comet.

The predicted date of perihelion was 1911, August 19·0656, Berlin M.T. The observation of R.A. indicates that this should be increased by 0^d·178, that of declination by 0^d·128. Giving the R.A. greater weight, we may take August 19·23 as a close approximation to the actual date. The error of the predicted value is larger than Professor Backlund expected: he notes in *Astr. Nachr.*, 4518, that it is not due either to errors in the computed perturbations or to a wrong mass of Mercury. Presumably, it arises from an alteration in its rate of acceleration, which has taken place several times before. There is a simple way of making pretty accurate forecasts of the dates of perihelion of this comet by taking advantage of the fact that eighteen revolutions of the comet are nearly equal to five of Jupiter, and consequently the perturbations nearly repeat themselves after this interval. Table A gives all the observed perihelion and the interval in days between each perihelion and the one eighteen revolutions later.

These are plotted in the diagram above (Figure 1) and it will be seen that they lie on a sinuous curve, from which the next return (that of 1914) has been predicted. It will probably not be much more than a day in error. The return of 1911 was predicted from the curve 0·8 days too late. The comet is most conspicuous at winter returns. Those of 1786, 1795.

1805, 1819 were all winter returns, at all of which the comet was independently discovered, its periodicity not being detected till after the 1819 return.

Five revolutions of Jupiter are equal to 21662·94 days.

MARS.—The season for this planet is again coming on. The opposition of November, though at a greater distance than the two last, is favourable on account of the planet's north declination. Work has already begun; Professor Lowell notes that successful photographs of the canals were taken in August, and that the two canals near Syrtis Major, announced as new at the last apparition, have again been seen. M. Jarry Desloges notes Mare Cimmerium and Lacus Solis as pale, while Trivium Charontis, Mare Sirenum, Titanum Sinus are dark. He sees many canals, broad and pale, but easy to distinguish, in spite of the planet's distance. Bathys appears as in 1909, but quite different from its 1907 aspect. The South Polar Cap is very small, and apparently often veiled by cloud or mist.

"Lowell Bulletin 50" contains a determination of the relative brightness of Mars' satellites. On 1909, September 16th, both were seen with aperture reduced to six inches, and it was estimated that as regards ease of seeing, Phobos was intermediate between Tethys and Enceladus. When at the same distance from the limb, Phobos was considered to be one and a-half magnitudes brighter than Deimos; the ratio of diameters is deduced as two and a-half to one, of volumes and masses fifteen to one. There was some evidence of variable brightness on the two sides of Mars, as in the case of Japetus. A Washington paper has lately appeared containing a determination of the orbits of these satellites in 1907, by Professor H. L. Rice. The epoch is 1907, July 0·0, G.M.T., and the elements are referred to the earth's equator. In each element the first value belongs to Deimos, the second to Phobos. Node 43°·42, 49°·70; Inclination 37°·75, 36°·42: Perimars 251°·0, 213°·6; ecc^{y} 0·0205, 0·0068.

It is interesting to compare these results with those deduced by Dr. Hermann Struve in 1898. He showed that under the joint influence of the equatorial protuberance of Mars and solar perturbation the pole of each orbit plane would describe a circle about a fixed point which, in the case of Phobos, is sensibly the same as Mars' North Pole, but in the case of Deimos is about 1° distant from it in the direction of the North Pole of Mars' orbit. The radii of the circles described by the poles of Deimos and Phobos are respectively $1\frac{3}{4}$° and 1°, and the amount of annual movement about 6°·7 and 162°. The perimars of each orbit advances at a rate sensibly equal to the retrogression of its pole. The R.A. of the pole of each orbit is Node −90°, and its North Polar distance is equal to inclination of orbit.

Perihelion.		Interval.		Perihelion		Interval.		Perihelion.
1786—Jan. 30·88	...	21739^{d}·7	...	1845—Aug. 9·61	...	21704^{d}·3	...	1905—Jan. 11·88
...	...	...	...	1848—Nov. 26·09	...	21704^{d}·8	...	1908—Apr. 30·91
...	...	...	...	1852—Mar. 14·71	...	21705^{d}·5	...	1911—Aug. 19·20
1795—Dec. 21·45	...	21740^{d}·6	...	1855—July 1·04	...	(21706^{d}·0)	...	(1914—Dec. 5·0)
...	...	...	...	1858—Oct. 18·37				
...	...	...	...	1862—Feb. 6·25				
1805—Nov. 21·51	...	21737^{d}·4	...	1865—May 27·93				
...	...	...	...	1868—Sept. 14·62				
...	...	...	...	1871—Dec. 28·81				
...	...	...	...	1875—Apr. 12·99				
1819—Jan. 27·26	...	21729^{d}·9	...	1878—July 26·17				
1822—May 23·97	...	21725^{d}·3	...	1881—Nov. 15·30				
1825—Sept. 16·28	...	21722^{d}·4	...	1885—Mar. 7·64				
1829—Jan. 9·75	...	21719^{d}·2	...	1888—June 28·00				
1832—May 3·99	...	21716^{d}·0	...	1891—Oct. 17·99				
1835—Aug. 26·37	...	21712^{d}·4	...	1895—Feb. 4·75				
1838—Dec. 19·02	...	21708^{d}·8	...	1898—May 26·86				
1842—Apr. 12·03	...	21705^{d}·4	...	1901—Sept. 15·47				

TABLE A.

In the diagram P_1 P_2 . . . P_7, D_1 D_2 . . . D_7 indicate the apparent positions of the poles of the orbits at the epochs 1877·7, 1879·8, 1892·6, 1894·7, 1896·9, 1907·5 all reduced to the equinox of the last date. Π, Δ are the fixed points of the two orbits, according to Struve, Π^{1}, Δ^{1} those revised by the 1907 observation. It will be seen that the alteration is small. The new positions should not be taken as definitive, since theory indicates that Π^{1} Δ^{1} should be parallel to Π Δ. Π is only 0°·01 from the North Pole of Mars' equator, which is on the line Δ Π produced. The diagram also shows N, the North Pole of Mars deduced by Professor Lowell from his own observations of the Polar caps combined with those of Schiaparelli, Lohse and Cerulli, and adopted in the Physical Ephemeris in the Nautical Almanac. N^{1}, the position recently given by Lowell from his own observations alone, is also shown. The agreement of N with Π is good in R.A., but there is a puzzling difference of 2° in N.P.D.

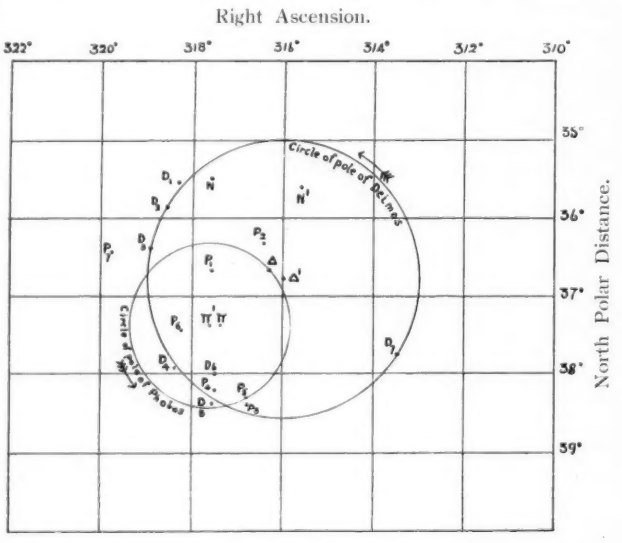

FIGURE 2.

Diagrams showing the positions of the poles of the orbits of Phobos and Deimos and of the planet Mars.

I think that ultimately the Satellite method will prevail, for their apparent orbits are much larger than the disc of Mars, and stellar points can be more accurately located than a large patch of irregular shape like the Polar cap. The fact that the accuracy increases with the apparent size of orbit is vividly shown by the much wider departures of the points marked P from the Phobos circle than of those marked D from the Deimos one. The pole of Deimos' orbit, will have been observed for a complete revolution about 1931, and after that the deduced position of the pole of Mars will probably have nearly reached finality.

VARIABLE STARS.—Mr. Joel Stebbins, who lately detected the secondary minimum of Algol with the selenium photometer, has detected a small variation of light in β Aurigae, a spectroscopic binary, showing that each star partially eclipses the other in the course of a revolution. The radius of each component is deduced as 2·6 that of the sun, the mass of each two and one-third that of the sun, and density one-third of his. Assuming a parallax of 0″·03, each component gives eighty times as much light as the sun at the same distance, while their intrinsic surface brightness is twelve times his. According to the diagram given, about one quarter of the diameter of each star is covered by the other at mid-eclipse. Mr. Stebbins has also discovered variability in δ Orionis, but his discussion on this is not yet complete. He proposes to examine other spectroscopic binaries, as, owing to their close proximity, partial eclipses must occur in a considerable proportion of them (*Astrophys. Journ.*, September).

Dr. Ejner Hertzsprung (*Astr. Nachr.* 4518) has detected a variation in Polaris of 0·17 magnitude in a period 3·9681 days, the same as that of its orbital motion given by the spectroscope. This is not, however, considered to belong to the Algol but to the Cepheid class, the variation being due to the different presentations of an elongated spheroid.

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

BOTANY AT THE BRITISH ASSOCIATION.—The meetings of Section K (Botany) at Portsmouth this year were of unusual interest owing to the presence of a large contingent of Continental and American botanists. During the four weeks preceding the commencement of the Portsmouth meeting these distinguished visitors, along with a number of British botanists, had made an extensive tour of this country, specially arranged for them by the International Phytogeographical Excursion Committee.

As might have been expected in the circumstances, Ecology formed an outstanding feature of the meetings, perhaps to the exclusion of other departments of Botany, so that the papers read were not quite so representative as usual of the science as a whole. Two entire days were devoted to Ecology, and several ecological papers were also given on the other days.

PRESIDENTIAL ADDRESS.—In his Presidential Address to the Section, Professor F. E. Weiss, of Manchester University, devoted himself mainly to the consideration of certain problems in Fossil Botany, not omitting that attractive phase of the subject, the Ecology of fossil plants. He pointed out that the possibilities of vegetable fossils preserved only as *impressions* in the rocks had been practically exhausted in 1870, when Sachs published his fascinating History of Botany, and dwelt upon the debt which botanists owe to the pioneers of modern Palaeobotany—Binney, Williamson, Renault, and others—who first showed that the *structure* of fossil plants is in certain cases preserved in the most remarkable manner by petrifaction and can be studied in microscopic preparations as effectively as has been the case with recent plants since the days of Grew and Malpighi.

After dealing with the question of the homology of the well-known *Stigmaria*, and reviewing the various explanations that have been put forward regarding the nature of the Stigmarian axis and its appendages, Professor Weiss concluded that various recent observations strongly support Williamson's view that *Stigmaria* was a down-growing prolongation of the stem of the *Lepidodendron* and *Sigillaria* to which it belonged, corresponding to the lower part of the stem of the present-day plant *Isoëtes*, the Stigmarian appendages answering to the roots given off by this portion of the plant in *Isoëtes*. Apparently the one thing now lacking to complete the chain of evidence in favour of Williamson's theory is the discovery of tips of *Stigmaria* rootlets showing structure.

Passing on to the remarkable Pteridosperms, which combine the characters of Ferns and Cycads, Professor Weiss called attention to the criticisms which Chodat has recently put forward against the too wholesale acceptance of the view that these seed-bearing, yet fern-like, plants form the "missing link" between Ferns and Cycads. According to Chodat the stem of a typical Pteridosperm like *Lyginodendron* presents purely fern-like characters in its structure, contending that the bundles of primary wood are *not* "mesarch," like the leaf-bundles of Cycads, but have only centrifugal wood; while the presence of secondary growth in thickness is no indication of Cycad affinity, but is merely comparable to what is found in various other fossil Ferns and Fern-allies. Chodat regards the "seed" of *Lyginodendron* as being merely a specialised development of the megaspore, corresponding to the seed-like organ found in the extinct Lycopod genus *Lepidocarpon*, and considers that the origin and the biology of this kind of "seed" must have been very different from those of the seeds of the Gymnosperms. In bringing forward Chodat's views, which run counter to those generally accepted in this country, on the nature of the Pteridosperms as the result of the brilliant discoveries of Oliver and Scott, Professor Weiss disclaimed any desire to urge their acceptance, but considered that Chodat's criticisms are sufficiently weighty to demand careful reinvestigation of the structure of some of the Pteridosperms.

Professor Weiss proceeded to make some criticisms of his own regarding recent theories on the origin of the Angiosperms from the Mesozoic group Bennettitales, pointing out that some botanists have "exceeded the speed-limit" in too rapid formulation and acceptance of such theories, and expressing his desire "to walk circumspectly in the very alluring paths by which they have sought to explore the primaeval forest, and not to emulate those rapid but hazardous flights which have become so fashionable of late."

In the latter part of his address, Professor Weiss dealt with the biology and ecology of fossil plants, a wide and promising field of research, of which only the fringe has yet been touched. Since the remains of plants are sometimes continuous through adjacent coal-balls ("calcareous nodules") it is clear that these concretions were mainly formed *in situ*, and that the plant remains they contain represent samples of the vegetable débris of which the coal-seam consists, giving us an epitome of the vegetation existing in Palaeozoic times on the area occupied by the coal-seam; while the Stigmarian rootlets in the underclay help to prove that the seam usually represents the remains of the Coal Measure forest carbonised *in situ*. This raises the question: What were the physical and climatic conditions of these primaeval forests? The structure of the roots of Calamites, Lepidodendra, and so on, with their large air-spaces, leads us to believe that, like many of their existing relatives, these plants were rooted under water or in water-logged soil; while the narrowness and the xerophilous structure of the leaves of these plants closely resembles the modifications met with in our marsh plants. None of the living Equisetales or Lycopodiales—the groups to which belong the Calamites, Lepidodendrons, and Sigillarias of the Coal Period—grow in salt marshes. Nor is it necessary to invoke the salinity of the marsh to explain the good preservation of the tissues of the plant remains, in view of the well-known power of humic substances to retard decay of vegetable tissues. Again, certain fungi found as parasites in coal plants seem to support the fresh-water nature of the swamp, just as the occurrence of a mycorhiza or "fungus servant" in some coal plants seems to indicate the presence of a peaty substratum. In some cases, millipedes and fresh-water shells occur in the Coal Measures among the plants; and the possible presence of marine organisms may be accounted for by occasional invasions of the Coal Measure swamps by the sea, especially as these swamps may well have been estuarine or formed near the sea.

Since so many types of vegetation are found in the Coal Measures, it is somewhat difficult to explain the occurrence, side by side, of land-plants and marsh-plants, though in certain cases it is clear that the remains of land-plants were carried into the swamp after its submergence below the sea. However, we can at the present day trace the gradual development of a

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lake type of vegetation from the reed-swamp through the marsh type to the peat-moor type, noting how one plant association makes place in its turn for another. Possibly the mixture of various types of vegetation found in coal-seams represents the transition from the open Calamitean or Lepidodendroid swamp to a fen or marsh with plentiful peat-formation, due to the gradual filling up of the stagnant water with plant-remains. In this transition from aquatic to more terrestrial types of vegetation, the tree-like forms rooted in the deeper water would continue to flourish, while there would be a luxuriant undergrowth of Ferns and Pteridosperms —this undergrowth being placed in excellent conditions owing to the narrow-leaved nature of the canopy of trees under which it grew, apart from the provision of a suitable substratum for its roots. This would explain the striking difference between the narrow-leaved tall Calamites and Lepidodendraceae, and the large-leaved Ferns and Pteridosperms, which spread out their foliage from short stems under the shade of the former.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON.), F.I.C.

DISTRIBUTION OF SUGAR IN THE BEET ROOT. —The distribution of sugar and non-sugar substances in the beet root has considerable importance, both from the point of view of vegetable physiology and of sampling for commercial purposes. Some work has already been done in this direction, but in the opinion of Messrs. Floderer and Herke (*Zeit. Zuckerind. u. Landw.*, 1911, XL, 385) its accuracy is open to question, owing to the defective methods of dividing the roots for the analysis. Accordingly, they have made a fresh investigation, using for the purpose fifty roots of uniform size, which they divided into ten transverse sections and sub-divided into concentric rings in the manner shown in the diagram. The respective corresponding pieces from each of the roots were mixed together so that in all nineteen separate lots were obtained for the analysis.

The results showed that the sugar (sucrose) was present in the greatest proportion in the innermost portion of the root, those sections between the middle axis and the part where the root began to taper being the richest. Thus the most sugar was found in the following sections, 14, 15, 19, 13, 12, 18, 17 and 16; and then in decreasing quantities in 11, 6, 8, 5, 4, 3, 7, 9, 2, 10 and 1. Whence it appears that the body of the root is richest in sugar and the crown the poorest.

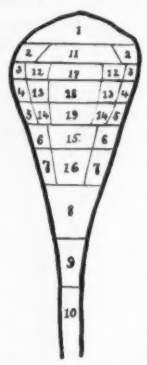

FIGURE 1.
A diagram illustrating the distribution of Sugar in the Beet-root.

With regard to the other constituents it was found that the total solid substances varied but little in any part of the root, with the result that a rise in the proportion of sugar was accompanied by a decrease in the amount of non-sugar substances. In fresh beet roots the proportion of soluble nitrogenous bodies was lower in the interior parts, while the mineral constituents (ash) varied inversely with the amount of sugar. A decrease in the amounts of potash and magnesia was observed on proceeding from 1 down to 15, where the sugar was present in greatest proportion, after which both substances increased with the fall in the sugar. It was not possible, however, to establish any relationship between the amounts of sugar and phosphoric acid.

"NON-INFLAMMABLE" FLANNELETTE. — *The Power Laundry*, of August, 1911, publishes the results of an investigation of the alleged non-inflammability of various kinds of flannelette on the market, which has recently been made in *The Lancet* laboratory.

In the case of some of the samples of material examined, the claim of non-inflammability was an obvious fraud, but in others the problem had been solved by loading the fabric with mineral salts. One of the principal dangers of flannelette is the tendency of the fine loose fluff, which becomes detached from the fibres, to flare up on contact with a flame. This tendency has been greatly reduced in certain products by weaving the fabrics with a much finer mesh, but it would seem that this only affords partial protection, and the risk of their catching fire increases after every washing.

Even in the case of materials rendered fireproof with mineral salts, a large proportion of the ash is washed out, and this may be sufficient to render the washed fabric unsafe. It is interesting to note, however, that in the opinion of *The Lancet* chemist, a definite compound appears to be formed between the cellulose and the mineral compound—apparently a salt of tin. This would explain the retention of a high proportion of the mineral constitutents even after repeated washings with soap and water.

The results obtained with twelve specimens of typical commercial flannelette and the conclusions drawn from them, are summarised in the following table .—

Fabric.	Original Ash. Per cent.	Ash after washing. Per cent.	Percentage of Residual Ash.	Percentage of Ash washed out.	Conclusion.
A	5·61	0·21	3·75	96·25	Unsafe
B	2·41	0·18	7·50	92·50	,,
C	2·18	0·81	37·16	62·84	Doubtful
D1	11·49	9·83	85·86	14·44	Safe
D2	11·69	7·66	65·53	34·47	,,
D3	12·49	9·00	72·00	28·00	,,
D4	18·73	8·86	47·30	52·70	,,
D6	20·77	17·50	84·26	15·74	,,
D7	21·35	15·15	70·20	29·80	,,
E	0·68	0·52	76·50	23·50	,,
F1	8·86	0·20	4·50	95·50	Unsafe
F2	1·87	*Nil*	*Nil*	100·00	,,

The reduction in inflammability corresponded with the increase of mineral matter, the samples "D6" and "D7," for instance, being the most resistant of all. Although fabrics treated with a sufficient proportion of suitable salts may thus be rendered fireproof, yet the question arises whether the natural properties of the cotton fibre may not be impaired by the presence of as much as a fifth part of mineral matter in the fabric, even though it is in combination with the cellulose. One point that is brought into prominence by this investigation is the unsatisfactory state of the law, which permits highly imflammable material to be sold at a higher price under the description "non-inflammable," and thus lulls the purchaser into a condition of false security. So far from reducing the death rate from this cause the sale of much of the "non-inflammable" flannelette on the market appears to have led to an increase of fatalities.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

THE FLOWING WELLS OF CENTRAL AUSTRALIA.—A paper by Professor J. W. Gregory, F.R.S., in the July and August numbers of *The Geographical Journal*, renews interest in these remarkable wells. This paper is by way of answer to the strictures of Mr. E. Pittman and others on Professor Gregory's views on the subject, as expressed in his book "The Dead Heart of Australia." In the latter he criticised the wasteful methods of utilizing the water from the wells, and combated the current view as to the origin of the supply, by which this wastefulness was excused. The water ranges through an area of some five hundred and eighty thousand square miles in Central Australia. The general view is that it is derived from the Eastern Highlands of Australia, and is continually replenished by percolation into water-bearing beds, from rainfall and rivers in that

region. The wasteful methods of use are justified on the ground that the replenishment so greatly exceeds the flow that the loss of water is unimportant. After a careful examination of the available evidence, Professor Gregory entirely rejects the view that the wells are supplied by rainfall, and are, in fact, of the normal artesian type. He holds that the water is derived from three main sources: (1) plutonic water from the interior of the earth; (2) residual water enclosed in the rocks at the time of their formation; (3) rainfall which percolated into the sandstones at an earlier geological period. If this is the case the supply is not unlimited, as is maintained by those who support the older theory, and a diminution of yield is to be expected; so much so that in the near future pumping may have to be resorted to in order to keep up the supply. According to Professor Gregory, this diminution has already begun in most parts of Queensland, South Australia and New South Wales.

The question is obviously of vast importance to Australia. If Professor Gregory's views are correct, the present waste is deplorable, and should be stopped as soon as possible. Fortunately, if it does become necessary to resort to pumping, the waste of water will be much lessened, and the decline of the water-level will become correspondingly slower.

PORPHYRITIC MONCHIQUITES IN BRITAIN.—Several very typical monchiquites have now been described from these islands, especially from Scotland. The monchiquites are characterised by their abundance of ferro-magnesian minerals, their groundmass of analcite, and frequently by the presence of remarkable ocelli, composed of radially arranged augite prisms surrounding a nucleus of analcite. A remarkable variety has recently been described by Professor W. S. Boulton, in a communication to the Geological Society. This rock is intrusive into the Old Red Sandstone of Monmouthshire, between Chepstow and Usk, and contains huge phenocrysts, attaining five or six inches in size, of augite and biotite. Nodules of olivine-augite rock are also described. This rock is compared with the monchiquites of Colonsay and Argyllshire. It is remarkably similar to a dyke-rock from Kilchattan in Colonsay, which carries enormous crystals of hornblende, biotite and augite. This rock, described in the Summary of Progress of the Geological Survey for 1909, page 52, is distinguished by containing nepheline, thus belonging to the rare group of nepheline-monchiquite. The writer of this column has discovered a third example of porphyritic monchiquite in Ayrshire. It occurs as part of an intricate complex intruding the agglomerate of a volcanic rock of Late Palaeozoic ("Permian") age, at Carskeoch Hill, near Patna. This rock carries huge phenocrysts of red barkevicitic hornblende, and biotite. Purple augite and olivine occur as a second and smaller generation of phenocrysts in the usual monchiquitic groundmass. The rock forms part of a complex in which teschenite, teschenite-picrite, essexite, and a new ijolitic rock containing much analcite, also occur. The age of this monchiquite is definitely fixed by its mode of occurrence. It belongs to the widespread suite of alkaline igneous rocks of Late Palaeozoic age so abundant in the West of Scotland. The Argyll, Mull and Colonsay examples are believed to be of Tertiary age, but may well be older. They have the usual north-west trend of the Tertiary suite, and cut the east-west dykes of quartz-dolerite which are of Late Carboniferous age. The Monmouthshire occurrence is at least post-Old Red Sandstone, and it is noteworthy that it is regarded either as a dyke with a north-westerly trend or as a volcanic plug. Another significant point is that the only other intrusion into the Old Red Sandstone of this district, that of Bartestree, near Hereford, has been described by Professor S. H. Reynolds, as teschenite, an analcite-bearing dolerite.

METEOROLOGY.

By JOHN A. CURTIS, F.R.MET.SOC.

THE weather of the week ended August 19th, as set out in the "Weekly Weather Report" issued by the Meteorological Office, was very fine generally, though thunderstorms were reported on the 13th and 19th. Temperature was above the average in all districts, the departures from the mean rising to 7°·8 in England, S.W. The highest readings were 92° at Tottenham, Cambridge, Raunds and Bath, on the 13th. In the extreme North it was much cooler, and at Baltasound and Lerwick the maximum for the week was only 60°. In the West the heat was not excessive, the maximum at Scilly being 76, and at Falmouth 74°. The lowest readings were 37° at Balmoral and at West Linton, and 39° at Narin and Wick. These were the only stations with minima below 40°; at many stations the minimum was not below 50°, and at some stations not below 60°. The temperature on the grass fell to 32° at Llangammarch Wells and to 33° at Crathes.

Rainfall was greatly in defect everywhere, except in London, where it was slightly above the normal. At many stations the week was rainless.

Bright sunshine was in excess of the average except in Scotland, E., where it was normal. In England, N.W., it was twice as much as usual, 72 hours (70%), while in England, S.E., the value was still higher, 77 hours (76%). The highest individual amounts reported were 88·9 hours (88%) at Brighton, 85·1 hours (84%) at Hastings, and 84·7 hours (84%) at Eastbourne.

The temperature of the sea water round the costs ranged from 54° at Lerwick to 72° at Margate.

The week ended August 26th was unsettled all over the country. Rain fell on several days and thunderstorms were experienced in almost all parts.

Temperature was still high, however, though the excess above the average was nowhere so great as in the preceding week. The highest readings were 86° at Wisley, and 85° at Cambridge and Raunds. In Scotland the maximum was only 73°, while in Ireland, at Killarney, it was 74°.

The lowest readings were 35° at Balmoral, and 36° at Markree Castle, Co. Sligo. At Westminster the temperature ranged between 56° and 81°. On the grass, however, frost was observed, the readings falling to 30° at Markree, and to 32° at Balmoral and at Llangammarch.

The rainfall varied a good deal. It was slightly above the average in Scotland, N., the Midland Counties, and England, S.E., and considerably above in England, N.E. In all other districts it was in defect. At several stations falls exceeding an inch in 24 hours were reported; at Portsmouth the amount on the 21st was 1·40 inches, 1·00 of which fell in half-an-hour.

Bright sunshine was in defect in all the Eastern Districts, and in excess in the Western parts. The most sunny district was the English Channel with 48 hours (49%) and the sunniest stations were Guernsey 55·7 hours (57%) and Pembroke 55·1 hours (56%).

The mean temperature of the sea water ranged from 54·8° at Berwick to 68·5° at Margate.

The week ended September 2nd, was fine as a whole, but in Scotland and the North of England rain fell rather frequently. Thunderstorms occurred at various stations during the earlier part of the week. Temperature was still high, the excess above average in England, E., amounting to more than 5°. The highest readings were 90° at Camden Square, Cromer and Hillington, with 89° at Greenwich, Cambridge and Norwich. The lowest readings were 34° at Marlborough, and 37° at Nairn and Balmoral. On the grass the temperature fell to 30° at Crathes and to 28° at Llangammarch.

Rainfall was in defect in all Districts except Scotland, N., and Scotland, W. At Glencarron the total fall for the week was 3·61 inches, and at Fort William 4·16 inches, which in each case was more than twice the average.

Bright sunshine was in excess in all the Districts, the district means varying from 40 hours, (40%) in Scotland, N., to 62 hours (65%) in the English Channel. The sunniest station was Jersey, 69·8 hours (74%). At Westminster the total duration for the week was 54·9 hours (58%).

The temperature of the sea water varied from 53° at Scarborough, to 70° at Margate.

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The weather of the week ended September 9th was very fine and dry generally, but with thunderstorms on the 4th and 8th. Temperature was again above the average, the excess in most parts of England being large, as much as 7°·8 in England, S.W., and 9°·3 in the English Channel. The highest readings were again very high, over 90° in many cases, and reaching 93° at Bath and Cambridge and 94° at Greenwich and Raunds. In the extreme North, however, the temperature was low; at Lerwick the maximum was only 59°. The lowest readings were 31° at West Linton, and 32° at Balmoral. On the grass the temperature was very low for the time of year, falling to 26° at Llangammarch, 27° at Crathes, and 30° at Balmoral and Colmonell.

Rainfall was again greatly deficient in all districts, and except in Scotland, N., the total fall was almost negligible. At many stations the week was rainless.

Bright sunshine was in excess except in Scotland, N., where it was just below the normal. The district means varied from 25 hours (26%) in Scotland, N., to 68 hours (73%) in Ireland, S. The sunniest stations werre Valencia 78·1 hours (84%), Jersey 77·3 hours (84%) and Tenby 74·9 hours (81%).

The mean temperature of the sea water varied from 54°·0 at Lerwick to 68°·0 at Eastbourne.

The week ended September 16th, was cooler and less settled than those immediately preceding it, with thunderstorms on the 11th and 12th. Temperature in many parts differed but little from the average, but in the Southern districts it was still above the normal. The highest readings were 88° at Greenwich, 87° at Margate and Tunbridge Wells, and 86° at Westminster, Cambridge and Geldeston. The minima fell below the freezing point on the 16th, to 31° at Colmonell, and to 28° at Llangammarch Wells. On the same day 33° was recorded at Hereford, while on the 13th the minimum at Balmoral was 32°. On the grass, temperature fell very low, to 14° at Llangammarch, 22° at Hereford and 27° at Colmonell.

Rainfall was considerably in excess in England, N.W., where it was more than double the average. In Scotland, N., it was dry, and only one-third of the usual amount was collected.

Bright sunshine exceeded the average, except in Scotland E. and in Ireland, the excess in England S.E. exceeding two hours per day. The sunniest stations were Eastbourne 59·5 hours (67%), Hastings 58·8 hours, (66%), and Guernsey 58·9 hours (66%). At Westminster the total duration was 48·3 hours (54%).

The temperature of the sea water was as low as 49° at Scarborough, and rose to 68° at Margate and at the Shipwash Lightship.

MICROSCOPY.

By A. W. SHEPPARD, F.R.M.S.,

with the assistance of the following microscopists:—

ARTHUR C. BANFIELD. ARTHUR EARLAND, F.R.M.S.
THE REV. E. W. BOWELL, M.A. RICHARD T. LEWIS, F.R.M.S.
JAMES BURTON. CHAS. F. ROUSSELET, F.R.M.S.
CHARLES H. CAFFYN. D. J. SCOURFIELD, F.Z.S., F.R.M.S.
C. D. SOAR, F.L.S., F.R.M.S.

MACROSPORIUM (FRIES).—The large compound spores of this fungus form handsome micro-objects, even for low powers, and are by no means difficult to obtain, especially in the autumn. The genus contains both saprophytic and parasitic species, though there is much doubt as to their exact limitations. Some are found growing on decaying cabbage leaves, bean pods and other vegetable refuse; a fine species *M. sarcinula* (Figure 1) is not at all uncommon on over-ripe melons, where it appears as black velvety patches, sometimes of considerable extent. It would be difficult, perhaps, to decide in many cases whether the fungus is a saprophyte or a true parasite. Another example, more frequent than welcome, is well-known to growers of tomatoes. It occurs both on the plant and on the fruit, but chiefly on the latter, and anyone wishing to obtain specimens for examination should look over some poor samples, when the parasite—as it almost certainly is in this case—will be found as black or olive-green patches of various sizes, usually sunk a little below the general surface. On cutting a thin slice from the region, it will be discovered that the underlying tissue is permeated by the somewhat coarse thread-like mycelium of the fungus, and occasionally the spores are developed in this situation. One species, named *M. solani*, attacks potatoes and may do much damage, particularly to the foliage and stems, though it also attacks the tubers, and may be transmitted, by means of the "seed" (dormant buds) used for planting, to a subsequent crop. This is now believed by competent authorities to be the same species as that found on tomatoes, *M. tomato* (Cooke), which appears likely, as the hosts are so closely related. There is a great similarity between all the species of the genus; the vegetative body consists of a web of mycelium ramifying in the substratum, but usually not very large in amount; this approaches the surface and there throws up short, jointed, mostly simple stems, which bear the large many septate spores. These vary a good deal in shape and size within the same species, and

FIGURE 1.

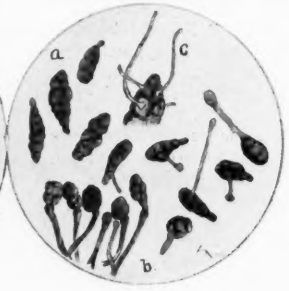

FIGURE 2.

each division—which is in effect a distinct spore—may under favourable circumstances put out a tube (hypha) which gives rise to a new fungus plant. An interesting experiment may easily be made with the tomato species. If some of the spores are placed on a fruit with uninjured cuticle, it will be found they are unable to penetrate it; but if a wound is made or they are placed on a cut surface, they quickly germinate and in a short time a fresh crop of the fungus and a plentiful supply of spores is obtained. It is necessary to keep the host in a suitable condition of warmth and moisture, which may be achieved by placing it in a saucer with a little water, covered by a tumbler, in a warm situation. The experiment illustrates the danger of infection through abrasions of the resisting outer surface, by what are known as "wound-parasites." Some of the species are known to be the conidia-bearing stage of an ascomycetous fungus. Dr. Cooke says that such is the case with *M. sarcinula*, and that it is a condition of the common little fungus *Sphaeria herbarum*, which is plentiful on various herbaceous plants, and looks—under moderate magnification — like little black wine flagons. Figure 1 is a representation of *M. sarcinula*. In Figure 2*a* are seen the spores of a species which was found growing inside a Tangerine orange. The hyphae appeared to be unable to emerge through the thick peel, but when a part of this was removed, the spores were produced in great quantity. At *b* is figured an example of *M. tomato*, on the right hand are shown some spores commencing to germinate. At *c* part of a spore is represented emitting a mycelium tube from nearly every division and is taken from Professor Massee's "Text Book of Plant Diseases." The species is *M. nobile*, which occurs on carnations.

J. B.

NOTE.—The figure of Anabaena—"KNOWLEDGE," September, page 354—was unfortunately wrongly placed. To agree with the text it should be turned till the part towards the *North* is at the *South-east*. J. B.

FIGURE 1. A Peach branch attacked by peach curl, *Exoascus deformans*.

FIGURE 2. Vertical section of a leaf of Peach infected with *Exoascus deformans*, × 500.

EXOASCUS DEFORMANS BERK. (PEACH CURL).—This fungus is the cause of a remarkable disease in Peach trees often proving fatal to young stock. Although the mycelium is perennial in the branches, the disease first becomes evident in early spring when the trees are producing their first leaves. Many of the leaves are at once virulently attacked and as a result they assume the remarkably thickened and curled appearance as seen in the first photograph. In colour they are yellowish-green splashed with red, probably due to the decomposition of the chlorophyll. As a consequence of this, photosynthesis is inhibited, resulting in a poor development of the plant. After a period of vegetation the fungus reproduces itself asexually. On certain localised areas of the leaf minute club-shaped bodies appear. These organs are asci, a reproductive structure typical of the large order of fungi—the Ascomycetes—of which *Exoascus* is the simplest representative. The contents of each ascus divides to form eight spores—ascospores, which again undergo division resulting in the formation of a large number of minute spores (see photograph) which on liberation carry on the work of destruction. Owing to the fact that the mycelium is perennial the disease is not easily eradicated. The usual method adopted by the nurseryman is the picking off and burning of all infected leaves.

CYSTOPUS CANDIDUS PERS. (WHITE RUST) ON *CAPSELLA BURSA PASTORIS* (SHEPHERD'S PURSE).—Figure 3. ***Cystopus candidus*** is an interesting member of the Oömycetes, a sub-class of the Phycomycetes or algal fungi—a name given to the group on account of the structure of the sexual organs, which are strikingly similar to those of the Siphonae, of which Vaucheria is an excellent type. The Phycomycetes are considered to be derived from the Siphonae.

The white patches well seen in the photograph are the sporangia of the fungus, the structure of which is demonstrated in Figure 4. The mycelium ramifies throughout the tissues of the stem, leaf and fruit, and eventually breaks through the epidermis giving rise to pustules of sporangia. These sporangia are produced in chains and on germination give rise to numerous swarm spores, which, given moist conditions, rapidly infect neighbouring plants. The sexual organs are antheridia and oögonia—arising *within* the host plant. The oögonia are spherical swellings formed at the ends of the hyphae, or intercalated throughout their length. The contents of the oögonium become differentiated into an oöspore and peripheral periplasm. The antheridia are tubular outgrowths, cut off from the parent hypha by a cell wall. After fertilisation the oöspore surrounds itself with a thick wall of a brownish colour, the surface of which is covered with irregular warts. After a period of rest the oöspores germinate. In the hard spore walls a fissure appears, and the contents of the spore, surrounded by the inner membrane, are pressed through the orifice. The protoplasm divides

FIGURE 3. Stems of Shepherd's Purse attacked by white rust, *Cystopus candidus*.

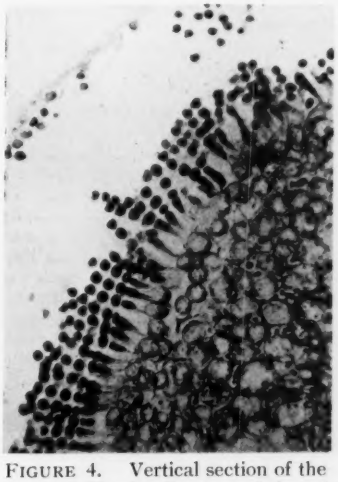

FIGURE 4. Vertical section of the stem of Shepherd's Purse infected with *Cystopus candidus*, × 200.

into a number of zoöspores, which are liberated by the dissolution of the membrane. H. GUNNERY.

QUARTERLY JOURNAL OF MICROSCOPICAL SCIENCE.—In the August number (Vol. V, Part 1) of the above journal there are one or two papers which may be of interest to our readers. The first to which we would draw attention is the interesting paper by Dr. W. E. Agar, devoted to the Spermatogenesis of *Lepidosiren paradoxa*. In the course of the research most attention was paid to the method by which the numerical reduction of the chromosomes takes place—owing to its importance in connecting the experimental knowledge of heredity with the structure and history of the germ cells. The sections of the testes for examination were mounted between two cover-slips instead of between cover-slip and slide. This allowed of the nuclei being examined and drawn from both sides. The advantages of this method are well shown in one of the beautiful plates illustrating this paper, where two figures of the same section are given, but drawn from opposite sides. The other paper we would draw attention to is by C. H. Martin, M.A., and Muriel Robertson, M.A., under the title of "Further Observations on the Caecal Parasites of Fowls, with some reference to the Rectal Fauna of other Vertebrates." Four new species are described and figured:—*Chilomastix gallinarum*, *Trichomonas gallinarum*, *T. eberthi*, *Trichomastix gallinarum*. The authors say that until the whole life-cycle of these animals are known the breaking-up of the complex series of forms inhabiting the caeca of fowls into good species is a matter of great difficulty. The Trichomonas affinities of these forms were disregarded by Saville Kent (Manual of Infusoria, 1881), who named them *Trypanosoma eberthi*. The plates illustrating this paper are deserving of very high praise. They show the nuclear changes that take place during division and the formation and development of the flagella.

MICROSCOPY IN THE NEW "ENCYCLOPAEDIA BRITANNICA."—The article devoted to the Microscope in previous editions of the "Encyclopaedia Britannica" now gives place to one by Dr. Otto Henker. The author first deals with the different forms of the simple Microscope and the optical theory relating to the use of a simple lens as a magnifier. The Compound Instrument is dealt with more fully. A short history precedes the more detailed treatment of the physical theory of the instrument, the diffraction problems underlying Abbe's theory of microscopic vision being fully explained and illustrated. A short paragraph is devoted to ultra-microscopy. The illuminating systems are next treated and here mention is made of some old methods revived for the production of dark field illumination. Special attention is here given to Siedentopf's Cardioid Condenser for use in this form of illumination. The various methods of obtaining binocular vision with the microscope are explained, and a section is devoted to mechanical arrangements under which heading Micrometry is dealt with. The article concludes with the methods of testing the instrument.

A special article is devoted to Microtomy by G. H. Fowler, Ph.D., F.L.S., F.Z.S., and this appears to be the only one having micro-technique for its subject. In it we have the theory of staining and the methods adopted for cutting sections and ribbon-sections. For Photomicrography we have to look under Metallography, where the method of obtaining photographs of the surface of metals is given. This subject has assumed such importance of late years that an article devoted to its methods would have been better than relegating it to the heading Metallography, which, of course, is but one of its many applications. The preparation of rock-sections and their examination by means of the micro-polariscope is fully and clearly explained under the heading of Petrology. This account of micro-technique, as applied to the examination of rock-sections, is excellent. Attention is drawn to the further refinement of microscopical method, consisting in the use of strongly convergent polarized light (konoscopic methods). This is obtained by using a wide-angled achromatic condenser above the polariser and a high-power microscopic objective.

ORNITHOLOGY.

By HUGH BOYD WATT, M.B.O.U.

BITTERN NESTING IN ENGLAND.—The belief that the Bittern (*Botaurus stellaris*), if given fair opportunity, would resume breeding in England has, happily, been substantiated this season. Miss E. L. Turner, when in Norfolk in July, was so fortunate as to assist in finding a young bird which she considered to be from four to five weeks old, and the Rev. M. C. H. Bird, in the course of a joint search, discovered the vacated nest. From its condition Miss Turner judges that more than one inmate must have been successfully reared. She gives a detailed account of her experiences in *British Birds* (September, 1911, pages 90-97), illustrated by photographs of the young bird and the nest.

The last eggs discovered in Norfolk were at Upton, near Acle, in 1868, and a young bird was killed at Reedham in August, 1886. Since then, although Bitterns have not infrequently appeared near their old nesting-places, they have not managed to breed. It seems not much more than a counsel of hope to wish that this bird may now re-establish itself as a regular nesting species, however greatly this is desired by bird-lovers.

BIRDS NEW TO SCOTLAND IN 1910.—The excellent and full reports on Scottish ornithology appearing annually in the *Annals of Scottish Natural History* are indicative of the enthusiasm with which bird-study is pursued in Scotland, and of the fresh discoveries and good results which reward the observers. In the July number of the *Annals* (No. 79, pages 133–149) the first instalment of the Report for 1910 is given by Misses E. V. Baxter and L. J. Rintoul, who draw attention to the number of species and sub-species added to the Scottish list during the year. These are eleven in all, and are as follows:—

1. Rock-thrush (*Monticola saxitilis*). One adult male; Pentland Skerries; Orkney, 17th May. Second occurrence of species in Britain.
2. Blyth's Reed-warbler (*Acrocephalus dumentorum*). One; Fair Isle; September. First record for Western Europe.
3. Marsh Warbler (*A. palustris*). One; St. Kilda; autumn. First time in Scotland.
4. Temminck's Grasshopper, or the Lanceolated Warbler (*Locustella lanceolata*). One; Pentland Skerries; 26th October. First record for Scotland and second for Britain.
5. American Pipit (*Anthas spinoletta pensilvanica*). One: St. Kilda; autumn. New to Britain. Only two other European records.
6. Hoary Redpoll (*Acanthis hornemannii exilipes*) Fair Isle, no data given. First record for Scotland.
7. Holböll's Redpoll (*A. linaria holboellii*). Occurred in some numbers in different places in eastern Scotland.
8. Yellowshank (*Totanus flavipes*). One; Fair Isle; no data given. First record for Scotland.

The undernamed are continental forms of birds of which there are British sub-species.

1. Redbreast (*Eritacus rubecula rubecula*). One; Isle of May; 22nd October.
2. Goldcrest (*Regulus regulus regulus*). Seven; Isle of May; between 10th September and 17th October.
3. Great Tit (*Parus major major*), One: Isle of May; 15th October. Another; Fair Isle; 17th November.

Note.—The first Scottish records of the Continental Song-Thrush (*Turdus philomelos philomelos*) and the northern Willow Warbler (*Phylloscopus trochilus eversmanni*) came both from the Isle of May, in the year 1909.

It will be noticed that practically all these new records are obtained from islands, an illustration of the importance of such outposts as bird-observatories, when watched with vigilance, carefulness and continuity. The records of Heligoland by Gätke are still unrivalled.

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GROUSE AND DISEASE.—Supplementing the note on page 355 *ante*, it should perhaps be said that Dr. Shipley, in the Report, explains that in the course of their researches during the inquiry, the investigators did not come across the "disease," which is so firmly believed in by sportsmen and gamekeepers. Twenty-three parasites of the grouse were found, and Dr. Shipley writes of the worm *Trichostrongylus pergracilis* as follows:—"The eggs give rise to larvae in about two days. The larvae surround themselves about the eighth day with a capsule or cyst, and undergo a 'rest cure.' After a period of quiescence they quickly change into second and active larval forms, which are minute, transparent, and quite invisible. These lead a perfectly free life, and in wet weather gradually squirm and crawl up among the leaves and flowers of the heather, where they remain until swallowed by the grouse. When once inside the bird, the larvae make their way along the alimentary track, and enter the caeca, where they rapidly develop into adults." Dr. Shipley also presents a word-picture of what would be seen, if, by means of a gigantic lens, a square yard of grouse moor were magnified a hundred times:—"The heather plants would be as tall as lofty elms, their flowers as big as cabbages, the grouse would be six or seven times the size of 'Chantecler' at the Porte St. Martin. Creeping and wriggling up the stem and over the leaves, and gradually yet surely making their way towards the flowers, would be seen hundreds and thousands of silvery white worms about the size of young earth-worms. Lying on the leaves and on the plant generally would be seen thousands of spherical bodies the size of grains of wheat, the cysts of the coccidium; and on the ground and on the plants, as large as split peas, would be seen the tapeworm eggs patiently awaiting the advent of their second host. It is perhaps a picture that will not appeal to all, yet it represents what, unseen and unsuspected, is always going on upon a grouse moor."—See "The Grouse in Health and Disease; being the final Report of the Committee of Inquiry on Grouse Disease." Two volumes. Illustrated. London, 1911.

MORE ABOUT THE CORN-CRAKE.—The distribution of this species (*Crex pratensis*), in England continues to call forth observations, and Mr. F. J. Stubbs has some apt remarks in *The Zoölogist* for August, 1911 (page 315). He points out that the disappearance of the species from the south-eastern counties of England dates from about 1850, and ascribes this to the change in agricultural methods that was in course then. The bird formerly bred in the corn-fields of the southern counties, which, under the old system of broadcast sowing, would be a real sanctuary. In a drilled cornfield this is not so; the nest could not be hidden and would be an easy prey to stoats. For this reason, and as the meadows are also unsafe and pasture fields inadequate, the bird has practically vanished as a nesting species.

The curious annual fluctuations of the bird are commented on by Mr. Stubbs, who says that the present year must be reckoned a corn-crake year in Lancashire, the species having been commoner than for many seasons.

In the recently published "Fauna of the Tweed Area" (1911), Mr. A. H. Evans reports that the bird is stated to be decreasing in some localities there, but that it is sufficiently plentiful in most parts. It is somewhat local, and almost absent from the coast-lands where there are few grass fields, but is common, not only in the lower valleys, but among the hills in "Tweed."

PHYSICS.

By ALFRED C. G. EGERTON, B.Sc.

INAUDIBLE SOUNDS.—The limit of perception of sounds of high pitch varies with the person. In general, persons lose their hearing for very high notes as they get older, and it appears that slight loss of hearing in the region of these upper frequencies begins to occur during quite an early age. Many cannot hear the sound of the bat squeaking, or of certain insects. Very acute sounds are audible up to thirty-eight thousand vibrations per second. Helmholtz gave as the lower limit, thirty vibrations per second, and a regular wave train of forty vibrations per second was the lowest musical note. Thus the ear can perceive vibrations ranging from thirty to thirty-eight thousand per second. No doubt higher sounds are common in nature: it is probable that animals have different ranges of perception. Many persons with average powers of hearing may be deaf to vibrations of thirteen thousand per second. In this connection it is interesting to note that old people often lack the ability to distinguish the letter "s" distinctly; the telephone and the phonograph also have difficulty in transmitting that letter. Now, the hissing sound when analysed into a wave form is a succession of waves with very minute irregularities on the face of the waves, and thus is equivalent in its facility to detection to a sound of very high pitch. Campbell and Dye have published, in *The Electrician*, an account of some work on the detection of inaudible sounds. The electric spark gives out waves of sound which are exceedingly short and far too high-pitched to be audible. The means by which the frequencies of these sound waves are measured are very simple. The oscillatory spark is arranged at the open end of a long horizontal glass tube along which is shaken out a little clyopodium powder. As the sound waves progress along the tube they set the lycopodium in motion, taking it away from the positions of least movement (the nodes) and laying it about where the air is in a greater state of turmoil. It is, in fact, the "Kundt's tube" arrangement which has been used to find the velocity of sound in various gases; for, by measuring the distance between the small heaps of dust produced by the particular note, the wave lengths can be found and hence the velocity (for the velocity equals the product of the frequency of vibration and the wave length). The method has various applications, for, from the velocity, the ratio of the amount of heat a gas can take up when free to expand and when confined can be found, and from this again whether the gas consists of a molecule possessing internal energy besides translation, or merely energy of translation: in the latter case the molecule consists of one atom. In this way the molecules of argon, helium, krypton, xenon, neon and mercury have been found to be monatomic. That is, the molecular weights equal the atomic weights. Campbell and Dye measured the distance between the striations produced in the lycopodium dust along the tube and found that they could measure in this way sounds of a frequency up to eight hundred thousand per second; their results seem to show that, since two sound waves are given out for each oscillation, the sound vibrations are double the frequency of the electrical oscillations.

THE AMPALL.—A few months back I mentioned this as one of the novelties in electrical instrument design which have been elaborated by Messrs. Paul. The instrument consists of a moving coil unipivot galvanometer connected to a pair of contact points a definite distance apart, such that if placed on a copper conductor of one square inch in cross section a reading of one thousand (= 2 millivolts) is obtained, if one thousand ampères are flowing through the wire. The contact block is strapped to the conductor, the cross section of which multiplied by the deflection of the unipivot millivoltmeter gives the current in ampères. The instrument can be used to measure direct currents up to any value and can be instantly applied without breaking the circuit; it also provides a means of testing the conductivity of joints, fuses and so on.

The unipivot system of suspension of the galvanometer needle is very satisfactory, as it allows of great sensitiveness with perfect portability. The moving coil has one pivot only in the centre of a sphere of iron. The circular coil swings freely about this sphere without touching the magnetic system. A circular well aged magnet is so situated that the field is concentrated across the gap where the sphere resides. The pivot is situated at the geometric centre of the coil, which is also the centre of gravity of the moving system. The arrangement, residing on the one pivot and held in position only by a hair spring, is thus capable of considerable sensitiveness; while the protection afforded by the sphere to the coil, pivot

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and rod bearing the pivot insures the safety of the moving coil system against a great deal of rough usage.

THE LUMINOSITY OF THE FIREFLY.—Coblentz and Ives have made an investigation of the light emitted by the firefly (*Photinus pyralis*). They find that the radiation controlled by the fly is all in the visible region of the spectrum—there appears to be very little ultra-violet radiation and no infra-red. The light is under control of the insect and does not appear to be stimulated by previous exposure to light, as with true phosphorescent substances. It is more probable that the light is due to oxidation of some complicated unstable fatty substance, the decomposition of which can be accelerated at will by the insect, perhaps by a catalytic agent.

MAGNETIC ALLOYS.—An alloy of 62·0 per cent. of copper, 25·0 per cent. of manganese, and 12·5 per cent. of aluminium, and also another alloy 43·4 per cent. of copper, 18·1 per cent. of manganese, and 40·0 per cent. of tin are the two most strongly magnetic of the non-ferrous alloys. Ross and Gray have recently studied the effect of annealing and quenching of these alloys and of such simpler and less magnetic alloys as copper manganese, manganese antimony, and manganese bismuth. They find that cooling to a very low temperature increases their susceptibility. Annealing improves their stability and quenching reduces the hysteresis (or lag of induced magnetism after the magnetising force). It appears to be difficult to explain why such alloys should be magnetic, though in most cases the magnetic properties seem to be due to the formation of solid solutions of binary systems (such as Mn_3 AL) in the rest of the material.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A.

MAGNALIA NATURAE; OR, THE GREATER PROBLEMS OF BIOLOGY.—This was the title of the notable address which Professor D'Arcy Wentworth Thompson, C.B., gave as President of the Zoölogical Section of the British Association. From its earliest beginnings, he said, Biology has been a great and complex and many-sided thing. Aristotle was all that we mean by naturalist and biologist; he gathered up and wove into his great web the varied lore of fishermen and bee-keeping peasants, as well as the learning of the Hippocratic and other schools of physicians and anatomists; but "every here and there, in words that are unmistakably the master's own, we hear him speak of what are still the great problems and even the hidden mysteries of our science," the magnalia naturae, inquiry into which is characteristic of the spirit of our time. The old questions of vital activity and organic form, of growth and reproduction, of heredity and variation, and the like, are being re-discussed, and many sciences are now being brought to the aid of biology. Very noteworthy is the renewed interest in the validity of the rival interpretations offered by the mechanistic and the vitalistic schools, whose antithetic views recall those of Democritus and Aristotle respectively. But whether we lean to the one side or the other, we must agree in the use of physical methods, and Professor Thompson devoted a considerable part of his address to showing that these are of service in studying form as well as function. Surface-tension, for instance, must count for much in determining form; it is one of the "means of morphogenesis," to use Driesch's phrase. After giving interesting examples, Professor Thompson expressed his belief that "the forces of surface-tension, elasticity and pressure are adequate to account for a great multitude of the simpler phenomena, and the permutations and combinations thereof, that are illustrated in organic form." . . . But "though we push such explanations to the uttermost, and learn much in so doing, they will not touch the heart of the great problems that lie deeper than the physical plane. Over the ultimate problems and causes of vitality, over what is implied in the organization of the living organism, we shall be left wondering still."

MOMENTUM IN EVOLUTION.—Professor Arthur Dendy made an interesting suggestion at the British Association in regard to cases where animals or parts of animals seem to have acquired some sort of momentum, by virtue of which they grow far beyond the limit of utility. Is there any constitutional brake on growth, and, if so, are there occasions on which the brake may be removed with results which ultimately prove fatal? Professor Dendy asks us to consider the internal secretions or "hormones" which in some cases act as a check on over-growth. If it were advantageous for a structure to grow big, and if that structure were one which grew abnormally big when a particular internal secretion was absent, then natural selection would favour those individuals in which the relevant glands were least developed or least efficient. The glands might disappear, or might cease to produce the particular hormone in question. The organ would go on growing larger; it would in the course of time reach its optimum; but the brake having been removed, further growth would proceed irrespective of utility. And as to exaggerated structures which never had any value as adaptations, Professor Dendy appeals to correlation. The removal of a gland which controlled the development of a frontal horn might be followed by the exuberant growth of an entirely useless excrescence.

ARISTOTLE'S LANTERN AS AN ORGAN OF LOCOMOTION.—Dr. James F. Gemmill communicated to the British Association a most interesting study of this wonderful piece of mechanism which Aristotle saw over two thousand years ago. There is a rhythmic swinging movement of the lantern, and progression is by a series of steps or lurches which are more or less sharply defined. In each step the urchin is raised on the tips of the teeth and a forward impulse is given, (*a*) by strong pushing or poling on the part of the lantern, (*b*) by similar but usually less effective pushing on the part of the spines, and (c), after a certain stage, by the influence of gravity. The lantern is then retracted and the teeth swing forward into position for initiating a new lurch. For ordinary locomotion over more or less horizontal surfaces under water the lantern is not needed, but Dr. Gemmill indicated various conditions, normal and experimental, in which it may be employed with effect. "The locomotor action of the lantern is a particular manifestation of a rhythmic functional activity, which can also subserve feeding, boring, respiration, and possibly also the maintenance of physiological turgescence in various internal cavities."

FOOD SUPPLY OF AQUATIC ANIMALS.—Dr. W. J. Dakin brought forward at the British Association some interesting corroborations of Pütter's theory that sea or fresh water is more or less a nutrient fluid, there being more organic carbon present in solution in the water than there is in the multitudinous plankton that swarms there. Dr. Dakin has tried to estimate the amount of carbon and oxygen required by certain aquatic animals per day to cover the loss due to metabolism. On the basis of this estimate, which is probably very approximate, a sponge 60 grammes in weight would require to filter several thousand times its own volume of water per hour in order to obtain sufficient food—"an altogether unthinkable piece of work." A big jelly fish (*Rhizostoma*) would require over seven millions of nauplius larvae per day. "It is quite impossible for such large quantities to be caught, and equally strange that remains of the creatures are so rarely found if they have been captured as food." Another striking fact, or result of calculations at all events, is that the "producers" (the plant-plankton), are insufficient for the "consumers" (the animal plankton). High alpine lakes, for instance, in which there is an outstanding production of animal plankton, are almost deserts as far as plant-plankton is concerned. What do these alpine crustaceans and rotifers feed on? Pütter's theory is the only solution of the riddle. We come to the idea that the water in lake and sea is food as well as drink. There is bread in the waters—according to the ingenious showing of Dr. Dakin.

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CORRESPONDENCE.

ASTRONOMICAL QUERIES.

To the Editors of "KNOWLEDGE."

SIRS,—I.—The subject of the brightness of a surface is one presenting various problems which it is impossible to discuss here. Mr. Bartrum will find a few of these in Parkinson's "Treatise on Optics," Chapters II and X. In estimating the brightness of Venus, Godfray assumes that the illuminated surface appears uniformly bright and of the same degree of brightness in all aspects. As this is not true, the results obtained are only approximate.

It is interesting to notice, although bearing only indirectly on the subject, that the half Moon does not give half as much light as the full Moon. The visible surface, except at full Moon, is darkened by shadows cast by the irregularities, and so the amount of light is diminished.

II.—The major semi-axis is called the mean distance, and must not be confounded with the average distance. This latter depends upon what is taken as the independent variable.

The mean distance of a planet from the Sun can be easily found by taking the Arithmetical Mean of the greatest and least distances. The former is a + ae, and the latter is a − ae; the Arithmetical Mean of these two is a, the Major Semi-Axis.

III.—The gradual decrease of the eccentricity of the Earth's orbit which has been going on for thousands of years, and which will continue for a long time yet, causes the mean motion of the Moon to increase. It is difficult to explain this in ordinary language, and a mathematical investigation is necessary.

Let S denote the mass of the Sun, R his distance from the Earth, and r the distance between the Earth and the Moon. When the three bodies are in a line the disturbing component of the Sun upon the Moon is

$$D = \mu S\left[\frac{1}{(R-r)^2} - \frac{1}{R^2}\right] = \mu S\left[\frac{r(2R-r)}{R^2(R-r)^2}\right]$$

where μ is a constant. This is evident, since the disturbing effect of the Sun upon the motion of the Moon is the difference of its acceleration upon the Earth and Moon.

Now r is very small compared with R, so that the above equation becomes $D = \frac{2\mu Sr}{R^3}$.

The disturbing acceleration in any part of the orbit of the Moon depends upon the distance of the Sun from the Earth, varying inversely as the third power of this distance. Let us find the average for a whole revolution of the Earth, which we may take to be performed in a time T, say. Let D^1 be the average disturbing effect $\therefore D^1 = \frac{4\mu Sr}{T}\int_0^{\frac{T}{2}} \frac{dt}{R^3}$

From Kepler's Law that the radius vector sweeps out equal areas in equal times, we obtain $\frac{1}{2} R^2 \frac{d\theta}{dt}$ = area described in unit time $= \frac{1}{2} h$ say.

$$\therefore R^2\, d\theta = h\, dt, \text{ or } \frac{dt}{R^3} = \frac{d\theta}{Rh}$$

$$\therefore D^1 = \frac{4\mu Sr}{Th}\int_0^{\pi} \frac{d\theta}{R}$$

The polar equation of a conic $\frac{L}{R} = 1 + e\cos\theta$, where L is the semi latus rectum $= \frac{b^2}{a}$ gives $\frac{1}{R} = \frac{a}{b^2}(1+e\cos\theta)$.

$$\therefore D^1 = \frac{4\mu Sra}{Thb^2}\int_0^{\pi} (1+e\cos\theta)\, d\theta.$$

Now $\int (1+e\cos\theta)\, d\theta = \theta + e\sin\theta = \pi$, taking π and o as limits

$$\therefore D^1 = \frac{4\mu Sra\pi}{Thb^2} = \frac{4\mu Sr\pi}{Tha(1-e^2)}$$

It is easily proved that

$$h^2 = \mu L C \text{ and } T = \frac{2\pi a^{\frac{3}{2}}}{\sqrt{\mu C}}$$

where C is a constant. (See Williamson and Tarlton's Dynamics, Chapter VII, Equations 30 and 31, for a simple proof.)

$$\therefore Th = 2\pi a^{\frac{3}{2}}\sqrt{L} = 2\pi a^{\frac{3}{2}}\sqrt{a(1-e^2)} = 2\pi a^2\sqrt{1-e^2}$$

$$\therefore D^1 = \frac{2\mu Sr}{a^3(1-e^2)^{\frac{3}{2}}}$$

It is easily seen that as e decreases, the denominator increases, and therefore D^1 decreases. The efficiency of the Sun in decreasing the attraction of the Earth for the Moon therefore decreases, and the mean motion of the Moon increases.

It should be said that the amount of variation calculated in this way, about six seconds a century, does not agree with the amount of acceleration obtained by comparing ancient with modern eclipses. It has been supposed that the discrepancy arose from a lengthening of the day, due to a retardation of the Earth's rotation from friction of the tides. The subject is, however, too long to discuss here.

(REV.) M. DAVIDSON.

THE FOURTH DIMENSION.

To the Editors of "KNOWLEDGE."

SIRS,—I was greatly interested in Mr. A. L. Annison's paper on "The Fourth Dimension" which appeared in the June number of "KNOWLEDGE," and I have been expectantly looking for the corollary to his useful piece of analytical reasoning; I may have missed it, but I certainly have not noticed it.

It appears to me that the logical deduction from his series of analogies is that the Fourth Dimension is Density (δ); I believe you will find that this fits in completely, and satisfactorily answers the demands of a Fourth Dimension.

Hence all physical substances could be expressed completely in terms of $L \times B \times H \times \delta$.

As this Dimension seems to have been overlooked because so well-known under the term of "weight," it appears to me probable that other dimensions may perhaps be recognisable as yet other well-known physical or chemical properties of matter.

ALFRED J. MULLINS.

COMETS 1911 *a* AND *c*.

To the Editors of "KNOWLEDGE."

SIRS,—The following observations of Wolf's and Brooks' comets, respectively 1911 *a* and *c*, were made on the evening of August 20th, 1911, by the aid of the forty-inch refractor of this observatory (Yerkes).

Wolf's comet (periodic), was very apparent in the forty-inch and was in a rich field. Small. Slight indication of a nuclear condensation. Near a small star.

Brooks' comet was observed, first with the four-inch finder of the great telescope. The nuclear condensation was a little more apparent than in previous evenings, but the comet was generally about the same. The nucleus and matter extending in all directions from it were all that were visible at one time, on account of the size of the field of view; the former, however, presented a fairly large disc and was nebulous in appearance. The light of the nucleus was practically white. There were several comparatively bright stars in the same field, which were actually visible through the head of the comet, apparently undergoing no loss in brilliancy whatsoever. The field itself was very luminous, and in some parts the nebulosity was more apparent than in others, which fact indicated the presence of a tail extending out into space, beyond the head of the comet.

FREDERICK C. LEONARD.

XUM

THE VELOCITY OF LIGHT.

To the Editors of "KNOWLEDGE."

SIRS,—A flash of "forked" lightning is visible to the eye, and seems to take an appreciable time to pass from the thundercloud to the earth. As the human eye is said not to be able to see anything that takes less than about one-tenth of a second to pass the line of vision, a flash of "forked" lightning must take more than one-tenth of a second to pass from cloud to earth, a distance of a mile or two, which would be equivalent to a velocity of about twenty miles per second.

If this be so, is there not a very great retardation in the velocity of light, at or near the level of the earth? If light travel at the average rate of one hundred and eighty-six thousand miles per second, and so great a retardation is caused by the density of the atmosphere near the earth's surface, may not light travel at a very much greater rate in space than one hundred and eighty-six thousand miles per second?

The experiments and observations for the calculation of the velocity of light were made at or near the surface of the earth; and if the earth's atmosphere does in any way reduce the velocity of light, would it not be possible and advisable to recalculate that velocity from experiments and observations made at observatories situated from five thousand feet to fifteen thousand feet above sea level?

G. R. GIBBS.

CLUSTERS AND NEBULAE.

To the Editors of "KNOWLEDGE."

SIRS,—September number, page 345. 1st column: "Clusters and groups of stars . . . which seem to be connected . . . by a force acting far more powerfully and at greater distances than gravitation."

I understand that gravitation balances the members of the Solar system with each other, and inferred that it has a similar effect in all other systems and on every system with every other. But Mr. Henkel suggests some other force which seems unnecessary.

G. M.

QUERIES AND ANSWERS.

Readers are invited to send in Questions and to answer the Queries which are printed here.

QUESTIONS.

51. GEOLOGY OF SOUTH DORSET.—Would one of your readers give me a few facts about the Geology of South Dorset—the strata, fossils and minerals. The region of greatest interest is the Swanage neighbourhood.

S. P. R.

52. GENIUS AND ISOLATION.—I have a theory that social isolation in youth is one of the primary causes of genius. Can some one quote me proverbs and facts in the lives of such men as Shakespeare and Napoleon, tending to demonstrate this hypothesis?

S. H. R.

53. STRANGE STARS.—Can any of your readers give me particulars as to the three strange stars seen last month on the right hand of the moon when nearly at the full in the South-East.

I am told they only appear once in one hundred years; is this so?

Some reference was made to these in a Scotch paper, but I have seen no mention in any of ours, or "KNOWLEDGE."

The stars are not now to be seen.

WALTER BRADSHAW.

REPLIES.

45. HEAT AND VACUUM.—The loss of heat by a liquid contained in an ordinary vessel is due mainly to conduction. Defining heat (in the sense of a high temperature possessed by a body relative to its surroundings), as a state of increased molecular motion, cooling results from conduction by surrounding matter. If, now, such conduction be almost wholly prevented by a vacuum jacket, the most potent cause of loss is removed, and cooling proceeds by radiation. This introduces the conception of ***radiant*** heat, which is quite distinct. Radiant heat is a wave disturbance which is radiated through space like light, and which produces a condition of increased molecular motion (heat) in any absorbing matter on which it falls. The spectral location of the radiant heat rays is in the infra-red. The full efficiency of a vacuum vessel can be obtained by making the walls highly reflecting.

CHARLES W. RAFFETY.

47. GRAVITY.—It is impossible for the atmosphere of our earth or of any of the Planets to prevent bodies flying off into space. If the absence of an atmosphere would mean that heavenly bodies could not retain anything on their surfaces, we might expect pieces of the Moon to be continually breaking off; for it is generally admitted that the Moon is practically devoid of an atmosphere. Of course, the resistance of the atmosphere will always diminish the velocity of a moving body, but this cannot have any connection with the point raised by "Ignoramus." For instance, if we could fire a bullet from the Earth with a velocity of about seven miles per second, it would fly off into space, the Earth losing control over it. This is based on the assumption that there is no atmosphere to hinder its motion; the presence of the atmosphere, however, would necessitate a velocity of projection greater than seven miles a second, in order that the bullet might not return. Evidently, however, "Ignoramus" is not considering such extreme cases as this, but seems to be under the impression that bodies would rise spontaneously in the absence of an atmosphere, and pass off into space. Not only is this a false idea, but bodies would actually weigh ***more*** if our atmosphere disappeared. The weight of one cubic foot of air at sea level and at normal temperature and pressure is ·0807 pounds. In accordance with the well-known law, that bodies immersed in a fluid lose a weight equal to the weight of fluid displaced, a body of volume one cubic foot would weigh ·0807 pounds less in air at sea level than in a vacuum. Evidently, then, there would be less tendency to fly off, generally speaking, if we had no atmosphere. The simple experiment of placing a few bodies under the receiver of an air pump, and then producing a vacuum, will show that there is no tendency for these bodies to fly off.

Whatever explanations may be given of the causes of Gravity, whether due to Etherial Tension or to any other cause, the fact that such a force exists cannot be denied. It surely cannot have been seriously advocated in the sermon referred to, that the earth retained bodies on its surface by atmospheric pressure without the force of Gravity!

HENRY F. CRICK.

NOTICE.

ARTIFICIAL RAIN.—In a little pamphlet under this title Mr. Emilio Olsson describes a sprinkling apparatus for crops which he claims will take the place of rain in times of drought, and he gives an account also of some experiments carried out in the way of electrifying the water used. A certificate from two engineers that the electrifying of the water reduced the total hardness and that it was able to kill locusts perfectly is included. Mr. Olsson's address is 19, Southampton Buildings.